California's Flood Future

Recommendations for Managing the State's Flood Risk

Attachment C:
History of Flood Management in California

FINAL November 2013

California's Flood Future is provided to help inform local, State, and Federal decisions about policies and financial investments to improve public safety, foster environmental stewardship, and support economic stability

FloodSAFE CALIFORNIA

PUBLIC SAFETY — ENVIRONMENTAL STEWARDSHIP — ECONOMIC STABILITY

US Army Corps of Engineers ®

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

FINAL

Attachment C: History of Flood Management in California

November 2013

STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

UNITED STATES ARMY CORPS OF ENGINEERS
FLOOD PLAIN MANAGEMENT SERVICES PROGRAM

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Acronyms and Abbreviations

AB	Assembly Bill
AF	acre-feet
BDCP	Bay-Delta Conservation Plan
CalEMA	California Emergency Management Agency
CALFED	Collaboration Among State and Federal Agencies to Improve California's Water Supply
CEAC	County Engineers Association of California
cfs	cubic feet per second
CLD	California Levee Database
CRS	Community Rating System
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
CVWD	Coachella Valley Water District
CWP	California Water Plan
Delta	Sacramento -San Joaquin River Delta
Delta IFEOP	Delta-Specific Integrated Flood Emergency Operations Plan
DPW	Department of Public Works
DSC	Delta Stewardship Council
DWR	California Department of Water Resources
FCWCD	Flood Control and Water Conservation District
FEMA	Federal Emergency Management Agency
FESSRO	FloodSAFE Environmental Stewardship and Statewide Resources Office
FIRM	Flood Insurance Rate Map
Flood Future Report	*California's Flood Future: Recommendations for Managing the State's Flood Risk*
FMFCD	Fresno Metropolitan Flood Control District
FY	fiscal year
GIS	Geographic Information System
gpm	gallons per minute
HMP	Hazard Mitigation Plan
ID	Irrigation District
IID	Imperial Irrigation District
IRWM	Integrated Regional Water Management
IWM	Integrated Water Management
KRFCP	Kings River Flood Control Project
LACDA	Los Angeles County Drainage Area
LACFCD	Los Angeles County Flood Control District
LADPW	Los Angeles Department of Public Works

LSJLP	Lower San Joaquin Levee Project
maf	million acre-feet
MHMP	Multi-Hazard Mitigation Plan
MWD	Municipal Water District
NFIP	National Flood Insurance Plan
NOAA	National Oceanic and Atmospheric Administration
NRCS	National Resource Conservation Service
O&M	operation and maintenance
OCFCD	Orange County Flood Control District
OES	Office of Emergency Services
OMRR&R	operation, maintenance, repair, rehabilitation, and replacement
PG&E	Pacific Gas and Electric
PPIC	Public Policy Institute of California
RCFCWCD	Riverside County Flood Control and Water Conservation District
RCTWG	Redwood Coast Tsunami Work Group
RD	Reclamation District
Reclamation	U.S. Bureau of Reclamation
RFCFCD	Redbank-Fancher Creeks Flood Control District
SAROC	Santa Ana River Orange County
SB	Senate Bill
SBCFCD	San Bernardino County Flood Control District
SDCFCD	San Diego County Flood Control District
SFHA	Special Flood Hazard Area
SFMP	Statewide Flood Management Planning
SJRFP	San Joaquin River Flood Protection
SPFC	State Plan of Flood Control
SRFCP	Sacramento River Flood Control Project
SRFP	Sacramento River Flood Protection
taf	thousand acre-feet
TM	technical memorandum
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Survey
VCWPD	Ventura County Watershed Protection District
WA	Water Agency
WCD	Water Conservation District
WD	Water District
WRA	Water Resource Agency

1.0 Introduction

1.1 Background

California is at risk for catastrophic flooding. All 58 California counties have experienced at least one flood event with significant consequences in the last 20 years, resulting in loss of life, and billions of dollars in damages. This report, *California's Flood Future: Recommendations for Managing the State's Flood Risk* (Flood Future Report), is the first product of the Statewide Flood Management Planning (SFMP) Program. The Program was developed under the FloodSAFE Initiative to expand California's flood management planning statewide. Specifically, the purpose of the SFMP Program is to make recommendations to inform flood management policies and investments in the coming decades by:

- Promoting a clear understanding of flood risks in California
- Garnering active support for partnerships at the local, tribal, State, and Federal levels[1]
- Coordinating with other California Department of Water Resources (DWR) planning efforts
- Identifying strategies and feasible next steps to better incorporate flood management into Integrated Water Management (IWM)
- Promoting an IWM approach for flood management solutions

The initial work of the SFMP Program was to collect information in support of the Flood Future Report, as well as to build unique partnerships with local flood management agencies, the County Engineers Association of California (CEAC), Federal Emergency Management Agency (FEMA), and the United States Army Corps of Engineers (USACE). Throughout the Flood Future Report, determinations about specific flood terms were made that may not represent the specific terms used by partner agencies. These are described in Textbox 1-1. A description of the Flood Future Report components, organization, and layout is provided in Appendix A.

Floods are naturally occurring phenomena in California. Floods can keep erosion and sedimentation in natural equilibrium, replenish soils, recharge groundwater, and support a variety of riverine and coastal floodplain habitats for some of California's most sensitive species. However, when floods occur where people live and work, the result can be a tragic loss of life and devastating economic impacts resulting from damaged critical infrastructure and vital public facilities, valuable agricultural land taken out of production, and disruptions to California's water supply system. Floods also can put species in danger by inundating and degrading habitat used by plants and animals for survival, which can result in temporary or permanent changes to native ecosystems.

[1] Hereafter in this document, the mention of governmental agencies is implicit to include tribal entities.

Textbox 1-1: Agencies Differ in Flood Terminology

One of the challenges in a multi-agency effort is resolving language and culture differences between agencies. Staff from both USACE and DWR who are responsible for developing this report have made a conscious choice to adopt certain terminology throughout the documents.

As an example, USACE has adopted ***flood risk management*** as the term to describe a broad flood program that encompasses planning, construction, and operation, maintenance, repair, rehabilitation, and replacement (***OMRR&R***). DWR executes a similar broad program, largely through its Flood Management Division. As a result, DWR uses the term ***flood management*** in much the same way USACE uses *flood risk management*.

Another term used throughout this document is ***100-year flood*** (or some other *x*-year flood). Although these terms are commonly used, both USACE and DWR prefer using ***1 percent chance flood*** (or a 1-in-100 chance event) to describe a flood that has a 1 percent chance of occurring in any given year. However, legislative language from 2007 directing DWR to undertake new planning using bond proceeds uses 100-year flood.

For Federally funded projects, the definition of operation and maintenance (***O&M)*** includes the local entity's financial obligation for OMRR&R of the implemented project. OMRR&R is a non-Federal responsibility when local, regional and/or State entities partner on a Federal project. DWR typically uses O&M to refer simply to operation and maintenance, although repair and rehabilitation are sometimes included depending on project specifics. References to O&M provided in this report include OMRR&R responsibilities when the project is a Federal/non-Federal partnership.

For this report, both agencies agreed that, although language and cultural differences remain, it is more important to focus on the shared responsibility of performing our flood risk management or flood management missions rather than the use of specific phrases not in each agency's respective culture. A glossary is included to help the reader understand specific terms used by flood professionals and those terms that are used to define specific agency missions.

Flood management is a process of preparing for, responding to, and recovering from floods that create risks for people and valued resources. Traditional approaches to flood management have led to the development of a large set of infrastructure solutions that have helped avoid damages to lives and property over many decades, although residual flood risk still exists across the state. Flood infrastructure has served California well; however, it has also led to some unintended consequences, such as loss of ecological function and redirection of flood risks upstream or downstream of infrastructure projects.

Flooding varies according to the diversity of landscape features, climate, and human manipulation of the landscape. All regions of California are susceptible to floods at different times of the year and in different forms—examples range from tsunamis in coastal areas to alluvial fan flooding at the base of hillsides, and from fast-moving flash floods to slow rise deep flooding in valleys. Flood risk varies across the state, generally increasing with storm frequency, as well as with development in floodplains. A smaller flood that causes minor damage might occur more frequently than a severe flood that causes major damage.

1.2 Purpose

This technical memorandum (TM), presented as Attachment C to the Flood Future Report, supplements the report with a more detailed history of flooding in the 10 major California Water Plan (CWP) hydrologic regions. The flood events in the CWP Sacramento-San Joaquin River Delta (Delta) and Mountain overlay regions are not included in a separate section in this TM because they are covered as part of the 10 hydrologic regions.

1.3 Overview of TM Organization

This TM is organized as follows:

- Section 1: Introduction – describes the purpose of this attachment and the SFMP Program background
- Section 2: Statewide Perspective – provides an overview of the history of flood in California
- Section 3: History of Flood by Hydrologic Region – provides a detailed history of flood for each of the hydrologic regions
- Section 4: Findings and Recommendations – provides a brief summary of findings and recommendations for steps forward
- Section 5: References – supplies a complete list of references used in researching information for this document

The TM is supported by the following appendices:

- Appendix A: Flood Future Report Components
- Appendix B: Historical Flood Events in California– table providing a list of flood events compiled from agencies throughout the state
- Appendix C: Detailed Historic Flood Information – detailed descriptions of significant flood events in California
- Appendix D: FEMA-Approved Multi-Hazard Mitigation Plans – a comprehensive list of FEMA-approved MHMPs in each hydrologic region, with corresponding dates of approval
- Appendix E: Dams, Weirs, Debris Basins, and Reservoirs in California – a compiled list of dams, weirs, debris basins, and reservoirs in the state
- Appendix F: Glossary – defines common terminology used throughout the Flood Future Report

1.4 Limitation of Information Sources

The information in this TM was compiled from more than 120 documents, each with differing levels of detail and completeness. Therefore, damage estimates have been left in the values stated in their original years. Information varied from source to source on specific flood historical events, flood infrastructure, and flood emergency procedures. If a flood event is documented in a county that falls within multiple hydrologic regions and no other specific information on the event is known, the event was added into all hydrologic regions for which that county is a part. This document represents a first attempt at compiling and synthesizing this information for the entire state.

2.0 Statewide Perspective

2.1 Introduction

California encompasses nearly 164,000 square miles, including more than 1,100 miles of coastline, and is home to almost 38 million people (Census, 2010). Today, almost 20 percent of the state's population is exposed to flooding. Californians have settled by and fought to control the 38 major rivers in the state—from the Klamath River in the north to the San Diego River in the south. Flows in California rivers vary dramatically based on meteorological conditions, hydrologic conditions, geology, and human development and encroachment patterns.

For example, the amount of water in the Sacramento River system is capable of varying from approximately 4,000 cubic feet per second (cfs) to more than 600,000 cfs, depending upon meteorological conditions. Water in the Sacramento River system typically rises gradually over time because reservoirs and other infrastructure control the system. Other rivers, such as the Los Angeles River, are dominated by urban effluent discharges during most of the year and then quickly swell when they carry flows from major storm events. In Los Angeles, storm systems typically produce their heaviest precipitation in the foothills and mountainous areas that surround the city. This precipitation can result in flash flows down the hillsides from higher elevations; the flash floods move to the ocean via channelized river systems developed to contain high flows through urbanized areas lower in the basin.

Flooding near the Sutter Buttes in Northern California

Although many water resource factors are affected by average conditions, some of the most important impacts, such as flooding, result from changes in local extremes rather than averages. Flooding occurs in all regions of the state in different forms and at different times, many covering large areas of the state. Over the last 60 years, California has experienced more than 30 major flood events, resulting in more than 300 lives lost, more than 750 injuries, and billions of dollars in disaster claims to the California Emergency Management Agency (CalEMA). Figure C-1 illustrates examples of historic flooding events in California.

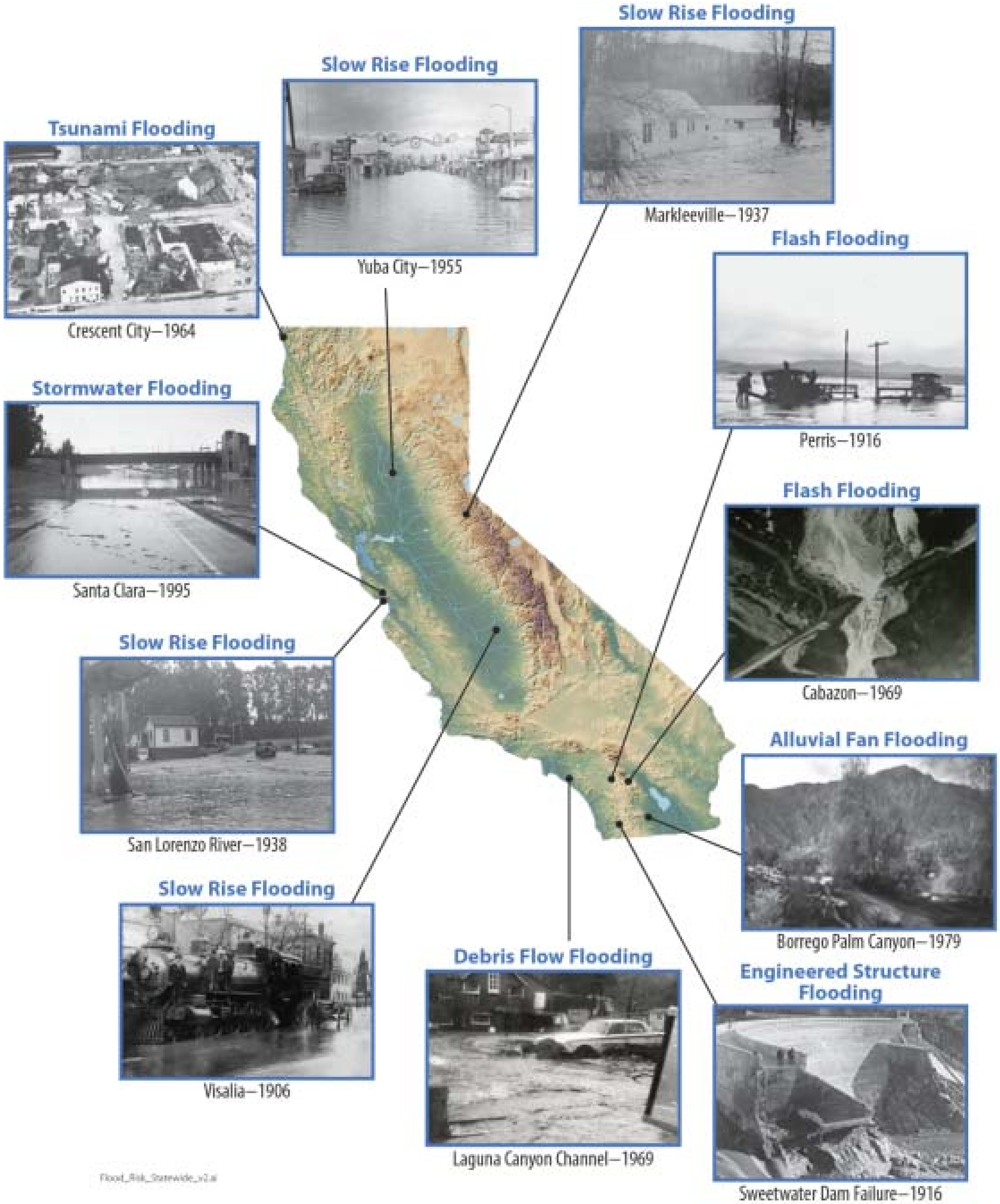

Figure C-1. Examples of Historic Flooding in California

Flooding is a natural occurrence in California and acts to replenish ecosystems with sediment and nutrients; however, as people and structures have moved into floodplains, the need for flood management has increased. In the 1800s, flood management was the responsibility of individual landowners (Kelley, 1998). Catastrophic floods in the late 1800s and early 1900s changed the perception of floods, prompting a series of statutes that increased the responsibility of Federal and State agencies for flood management, as well as the development of flood management infrastructure. During this timeframe, flood management consisted primarily of structural solutions such as dams, levees, reservoirs, and floodwalls.

In the 1960s, studies revealed that continued development in floodplains was increasing residual flood risk. Residual risk is the likelihood of damage or other adverse consequence remaining after flood management actions are taken. As a result, local, State, and Federal agencies began developing policies and programs that managed floodplains in addition to implementing structural solutions for controlling floodwater (FEMA, 2010). These nonstructural solutions have evolved to include emergency preparedness, response and recovery, flood insurance, operations and warning systems, flood awareness efforts and restoration of natural floodplain functions (in some cases).

Flood management practices are evolving toward an IWM approach. IWM is a strategic approach to planning that seeks to combine specific flood management, water supply, and ecosystem actions to deliver multiple benefits.

Today, more than 7 million Californians, or one in five, live in the 500-year floodplain, and approximately $580 billion in assets (crops, structures, and public infrastructure) are exposed to flooding. This estimate does not include the impacts of future development, population changes, climate change, or costs due to loss of major infrastructure and critical facilities, as well as losses to State commerce. This section provides an overview of issues facing flood management agencies, flood management tools and practices, and background information to develop the flood history for the individual hydrologic regions.

2.1.1 Types of Flooding in California

Flooding is a significant statewide threat to life safety, the environment, and the economy; however, the impacts of flood events vary across the state because of the diversity in geographies, climates, and demographics. Several types of flooding occur throughout California due to variations in:

- Weather and climate patterns (e.g., El Niño, La Niña, Pineapple Express, Atmospheric River)
- Hydrologic features
- Composition of soil and bedrock
- Type and density of vegetation
- Patterns of land use
- Expected level, age, and condition of flood management infrastructure

Flood Risk

Many Californians do not understand their risk of flooding or how flooding could impact the economy of the State. All Californians could be impacted by a major flood, either directly or indirectly, where they live, work, or play. A floodplain is never fully protected with 100 percent certainty; at best risk can only be reduced.

Atmospheric River

A weather pattern that forms a narrow corridor of concentrated moisture in the atmosphere that drops torrential rains as it passes over land.

These conditions result in floods that can differ in characteristics such as warning time, duration, depth, and how much is lost, depending on where, when, why, and how the flooding occurs.

The types of flooding (Figure C-2) in California can be divided into eight categories:

For the purpose of this document, a significant flood is characterized by one or more of the following:

- ✓ Covering more than 75 percent of the region
- ✓ Resulting in damages totaling more than $10 million (2012 dollars)
- ✓ Having peak discharge and peak flows that exceed design criteria
- ✓ Resulting in the loss of human life
- ✓ Being generally accepted as a large event in a particular region

- **Flash flooding** – Quickly forming floods with high-velocity flows. Often caused by stationary or slow-moving storms. Typically occurs on steep slopes and impermeable surfaces, and in areas adjacent to streams and creeks.
- **Slow rise flooding** – Gradual inundation as waterways or lakes overflow their banks. Most often caused by heavy precipitation, especially with heavy snowmelt. This type of flood includes riverine flooding in deep floodplains and ponding of water in low-lying urban areas, as well as gradual flooding in areas adjacent to local streams and creeks. In California, slow rise flooding can mean hours, days, and sometimes weeks—but not months as is possible in the Midwest.
- **Debris flow flooding** – Flows made up of water, liquefied mud, and debris. Can form and accelerate quickly, reach high velocities, and travel great distances. Commonly caused by heavy localized rainfall on burned hillsides devoid of vegetation.
- **Alluvial fan flooding** – Flows of shallow depth and high velocity, with sediment transport, along uncertain flow paths on the surface and at the toe of alluvial fans. Typically caused by localized rainstorms, often with snowmelt.
- **Coastal flooding** – Inundation at locations normally above the level of high tide. Often caused by storm surge occurring with high tide.
- **Tsunami flooding** – High-speed seismic sea waves triggered by mass movement that displaces a large volume of water. Causes include earthquakes and underwater landslides. Impact on land depends on wave height and inundation area.
- **Stormwater flooding** – Localized flooding that occurs in urbanized areas during or after a storm event. Generally, the extent of flooding is confined to a smaller area compared to other types of flooding. Local stormwater flooding usually results from clogged or overwhelmed storm drain systems that became incapable of conveying stormwater runoff efficiently to outfalls or into creeks and rivers.
- **Engineered structure failure flooding** – Flooding as a result of dam failure or levee failure presents the potential of catastrophic impact, depending on amount of water impounded and location of populated areas downstream.

All California communities are at risk of at least one of these flood types, and most California communities are vulnerable to more than one type. Table C-1 provides a summary list of significant flood events in California and the flood management actions that were taken in response to the events.

Figure C-2. Types of Flooding in California

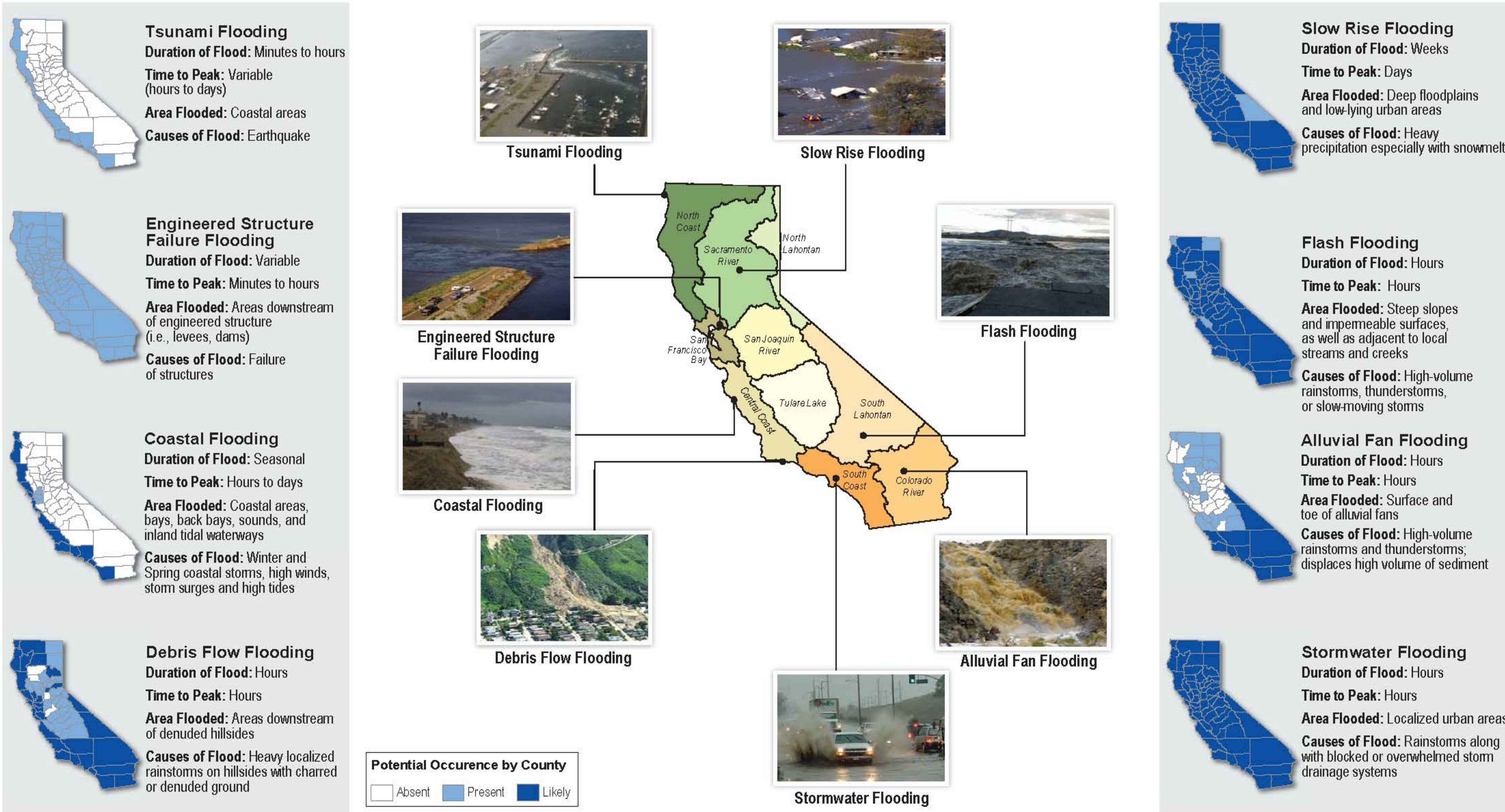

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Table C-1. Selected Historical California Flood Events and Flood Management Actions Taken in Response

Year of Flood	Location (Hydrologic Region)	Flood Type	Flood Management Actions Taken in Response to Flood Event
1805, 1825, 1849	Statewide	Slow Rise, Flash Flooding	Development of the California Flood Control Program (DWR, 1965)
1861-1862	Statewide "The Great Flood"	Slow Rise Flooding	Levee construction
1867-1868	Tulare Lake	Slow Rise Flooding	Channel modifications/improvements
1878	Point Sal, Avila at Cayucos (Central Coast)	Tsunami Flooding	
1896	Santa Barbara (Central Coast)	Tsunami Flooding	
1905-1907	Colorado River (Salton Sea)	Engineered Structure Failure	Repair of Inland Structure
1916	Sweetwater Dam (South Coast)	Engineered Structure Failure	Repair of dam
1927	Santa Ana River, Perris (South Coast)	Flash Flooding	Channel modifications/improvement
1928	St. Francis Dam (South Coast)	Engineered Structure Failure	Replaced by two other dams, Bouquet Reservoir and Castaic Dam
1937	Russian River (North Coast), Kings River (Tulare Lake)	Slow Rise Flooding	Construction of Coyote Valley Dam (Lake Mendocino), construction of Pine Flat Dam
1938	Los Angeles River (South Coast), Inland Desert Areas (South Lahontan)	Flash Flooding	Lining of channel bed and slopes
1939	Southern California Desert Areas (Colorado River)	Flash, Alluvial, Debris Flow Flooding	
1945	San Lorenzo River (Central Coast)	Slow Rise Flooding	Channel modification improvements
1950	Central Valley (San Joaquin, Tulare Lake)	Slow Rise Flooding	Development of the California Flood Control Program (DWR, 1965)
1955-1956	"1955 Christmas Flood" (Statewide)	Slow Rise Flooding	Construction of levees, reservoirs, and bypasses
1958	Statewide	Slow Rise Flooding	Development of the California Flood Control Program (DWR, 1965)
1962	North Coast, North Lahontan, Sacramento, San Francisco Bay, San Joaquin, and Tulare Lake	Slow Rise Flooding	Development of the California Flood Control Program (DWR, 1965)
1964	Crescent City (North Coast)	Tsunami Flooding	Tsunami mitigation measures, including harbor improvements and warning systems
1964	Central Coast, Sacramento, San Joaquin, North Coast, North Lahontan, San Francisco Bay, and Tulare Lake	Slow Rise, Debris Flow Flooding	Variety of actions taken statewide as a result of the December 1964 floods.
1965	South Coast	Flash, Debris Flow Flooding	Channel modifications/improvements
1966	Central Coast, Sacramento, San Joaquin, South Coast, South Lahontan, and Tulare Lake	Alluvial, Debris, Flash, Slow Rise Flooding	Channel modifications/improvements
1969	South Coast	Flash, Slow Rise Flooding	Construction of Mojave River Dam Channel modifications

Table C-1. Selected Historical California Flood Events and Flood Management Actions Taken in Response

Year of Flood	Location (Hydrologic Region)	Flood Type	Flood Management Actions Taken in Response to Flood Event
1969-1970	Statewide	Flash, Slow Rise Flooding	Channel modifications/improvements
1974	Sacramento River	Slow Rise Flooding	Channel modifications/improvements
1976	Colorado River	Flash, Alluvial, Debris Flow Flooding	Channel modifications/improvements
1977	Colorado River and South Coast	Flash, Alluvial, Debris Flow Flooding	Repair Flood Control Basins
1978	Statewide	Stormwater, Flash Flooding	Variety of actions taken locally to address stormwater flooding. Channel modifications/improvements
1980	Statewide	Flash, Debris Flow Flooding	Channel modifications/improvements
1983	Statewide	Slow Rise, Engineered Structure Failure, Debris Flow, Coastal Flooding	Channel modifications/improvements, Levee repair
1986	"St. Valentine's Day Storm" (Central Coast, North Coast, North Lahontan, Sacramento, San Joaquin, San Francisco Bay)	Slow Rise, Coastal Flooding	Channel modifications/improvements, Levee repair, new reservoir operating criteria
1995	Statewide	Flash, Debris, Coastal Flooding	Channel modifications/improvements and bypass tunnel. 48 of 58 counties declared a state of emergency. Integrated flood management – living river concept
1996 -1997	Central Coast, North Coast, Sacramento River, San Francisco Bay, San Joaquin, and South Coast	Engineered Structure Failure, Slow Rise Flooding	Channel modifications, set-back levee construction, and levee repair
1998	Santa Maria River (Tulare Lake Region)	Flash, Slow Rise Flooding	Levee reconstruction and upgrading
2003	Colorado River	Flash, Alluvial Fan, Debris Flow Flooding	Construction/rehabilitation of debris basin
2004	San Joaquin River	Engineered Structure Failure	Rebuild levee and dewater island
2005	South Lahontan	Flash Flooding	Debris dam cleaning and rehabilitation
2006	San Francisco Bay	Slow Rise Flooding	Channel modifications/improvements and ecosystem restoration
2008	San Diego (South Coast)	Flash Flooding	Channel modifications/Improvements
2008	Mount Whitney, South Coast, South Lahontan	Debris Flow Flooding	
2011	Coastal	Tsunami Flooding	Repairs ongoing

Peak Flows

Tracking peak flows, as shown in Table C-2, provides information on record stage and discharge flood levels, along with mean annual volume for the larger streams around the state. Peak flows indicate high runoff events caused by rainfall, snowmelt, or a combination of the two. Tracking peak flow information provides flood managers a way to quantify maximum discharge from events and to estimate water elevations for potential flooding, and downstream flooding. The stations included in Table C-2 were selected from all U.S. Geological Survey (USGS) gauging stations in the hydrologic region, according to the following criteria:

- The watercourse must be a natural stream with a watershed of at least 100 square miles.
- The station must have a reasonably continuous record of discharge from 1996 to the present.
- The station must be far enough from other stations on the same river to reasonably represent a separate condition.
- Stations in well defined watercourse locations such as deep canyons are omitted, unless particularly important to the overall flood situation.

In Table C-2, the selected streams are listed north to south within the hydrologic region. If data for a stream exist in more than one gauge, the most downstream gauge is considered.

Table C-2. Record Flows for Selected Streams Statewide

Stream	Location	Mean Annual Runoff (taf*)	Peak Stage of Record (feet)	Peak Discharge of Record (cfs)	Date of Peak Discharge	Hydrologic Region
Eel River	at Fernbridge	N/A	29.5	800,000	12/23/1964	North Coast
Klamath River	near Klamath	12,690[b]	63.0[a,d]	557,000	12/23/1964	North Coast
Mad River	near Arcata	997[b]	30.7	81,000	12/22/1964	North Coast
Mattole River	near Petrolia	945	36.6	90,400	12/22/1955	North Coast
Navarro River	near Navarro	375	40.6	64,500	12/22/1955	North Coast
Redwood Creek	at Orick	734	28.2[a]	50,500	12/22/1964	North Coast
Russian River	near Guerneville	1,663	49.7[a]	102,000	2/18/1986	North Coast
Salmon River	at Somes Bar	1,304	46.6[c]	133,000[c]	12/22/1964	North Coast
Scott River	near Fort Jones	463	25.3	54,600	12/22/1964	North Coast
Smith River	near Crescent City	2,720	48.5	228,000	12/22/1964	North Coast
Trinity River	at Hoopa	3,568[b]	57	231,000	12/22/1964	North Coast
Van Duzen River	near Bridgeville	624	24	48,700	12/22/1964	North Coast
Napa River	Near Napa	155[b]	30.5[a]	37,100	2/18/1986	San Francisco
San Lorenzo River	At Santa Cruz	94	23.1	30,400	12/23/1955	Central Coast
San Benito River	At State Highway 156, near Hollister	26	13.5	34,500	3/3/1998	Central Coast

Table C-2. Record Flows for Selected Streams Statewide

Stream	Location	Mean Annual Runoff (taf*)	Peak Stage of Record (feet)	Peak Discharge of Record (cfs)	Date of Peak Discharge	Hydrologic Region
Salinas River	Near Bradley	378[b]	23.4	120,000	3/11/1995	Central Coast
Sisquoc River	Near Garey	38	23.5[a]	33,600	3/1/1983	Central Coast
Santa Ynez River	At Narrows	94	24.2	80,000	1/25/1969	Central Coast
Ventura River	Near Ventura	51[b]	29.3[a]	63,600	2/10/1978	South Coast
Santa Clara River	At Montalvo[c]	122	17.4	165,000	1/25/1969	South Coast
Sespe Creek	Near Fillmore	93	25.0[a,d]	85,300	1/10/2005	South Coast
Piru Creek	Above Frenchman's Flat	31	N/A	36,000	2/25/1969	South Coast
Malibu Creek	At Malibu Canyon[f]	21	21.4	33,800	---	South Coast
Ballona Creek	At Culver City[f]	36	16.0	32,500	---	South Coast
Los Angeles River	At Long Beach[f]	194	18.3	128,700	---	South Coast
Rio Hondo	At South Gate[f]	38	15.4	48,100	---	South Coast
Rio Hondo	At South Gate[f]	38	15.4	48,100	---	South Coast
San Gabriel River	Below Santa Fe Dam, near Baldwin Park	47	22.2	30,900	1/26/1969	South Coast
Santa Ana River	At Municipal Water District crossing, near Arlington	1152	16.6	47,800	1/11/2005	South Coast
Santa Margarita River	At Ysidora	452	20.5	44,000	1/16/1993	South Coast
San Diego River	At Mast Road, near Santee	18	18.1	45,400	2/16/1927	South Coast
San Jacinto River	Near San Jacinto	14	5.31	45,000	2/16/1927	South Coast
American River	At Fair Oaks	2,719[b]	28	134,000	2/19/1986	Sacramento River
Battle Creek	Below Coleman Fish Hatchery, near Cottonwood	3702	15.8[a,c]	35,000[c]	12/11/1937	Sacramento River
Bear River	Near Wheatland	299[b]	24.3[a]	48,000	2/17/1986	Sacramento River
Butte Creek	Near Chico	301	17.5[a]	35,600	1/1/1997	Sacramento River
Cache Creek	At Yolo	392	86.4[a]	41,400	2/25/1958	Sacramento River
Cottonwood Creek	Near Cottonwood	650	21.6	86,000	3/1/1983	Sacramento River
Cow Creek	Near Millville	503	26.8[a,c]	48,700	11/16/1981	Sacramento River
Feather River	At Oroville	4,491[b]	25.5	161,000	1/2/1997	Sacramento River

Table C-2. Record Flows for Selected Streams Statewide

Stream	Location	Mean Annual Runoff (taf*)	Peak Stage of Record (feet)	Peak Discharge of Record (cfs)	Date of Peak Discharge	Hydrologic Region
McCloud River	Above Shasta Lake	567[b]	29	51,300	1/1/1997	Sacramento River
Mill Creek	Near Los Molinos	222	23.4	36,400	12/11/1937	Sacramento River
Pit River	Near Montgomery Creek	3,552[b]	74.7[a]	73,000	1/24/1970	Sacramento River
Sacramento River	Above Bend Bridge, near Red Bluff	9,514[b]	36.6[a]	170,000	12/22/1964	Sacramento River
Yuba River	Near Marysville	1,746[b]	91.6	161,000	1/2/1997	Sacramento River
Cosumnes River	At Michigan Bar[d]	362	18.5	93,000	1/2/1997	Sacramento River
Yolo Bypass	Near Woodland[d]	2,340[b]	34.9	374,000	2/20/1986	Sacramento River
Cosumnes River	At Michigan Bar	362	18.5	93,000	1/2/1997	San Joaquin River
San Joaquin River	Near Vernalis	3,308	34.9[a]	79,000	12/9/1950	San Joaquin River
Stanislaus River	At Ripon	707	63.3	62,500	12/24/1955	San Joaquin River
Tuolumne River	Below La Grange Dam, near La Grange	751	28.4	58,900	1/3/1997	San Joaquin River
Kern River	Near Kernville	344[b]	24.4[a]	60,000	12/6/1966	Tulare Lake
Middle Fork Kaweah River	Near Potwisha Camp[c]	105[b]	29.0	46,800	12/23/1955	Tulare Lake
Deep Creek	Near Hesperia	53	33.3[a, c]	46,600	3/2/1938	South Lahontan
Colorado River	Below Palo Verde Dam, Arizona-California	5,033[d]	17.9[a]	423,003	6/30/1983	Colorado River

The streams in this table were selected based on the basis that each had over 30,000 cfs in the peak discharge of record, and flow measurements were taken at the gauge station farthest downstream. One exception was the Colorado River, where the flow provided was taken at an upstream location due to water diversions.

*taf = thousand acre-feet

Notes:

[a]Different date than peak discharge

[b]Most recent but less than period of record

[c]Due to backflow

[d]Outside period of record

2.1.2 History of Flood Response

Flood management in California has evolved over time with a variety of actions developed to address specific regional concerns and reduce residual flood risk. The different actions have been the impetus for the formation of a complex array of agencies to manage flood risk. The types of agencies involved in flood management change with geography, regional preference, experience, and flood type. These agencies have different governance structures, which complicates coordination and funding of projects across the state. Historically, development of major flood management infrastructure has been undertaken on a project-by-project basis, often with technical and financial support from State and Federal agencies such as DWR and USACE. Upon Federal flood management project completion and acceptance by the local entity, local agencies assume operations, maintenance, repair, rehabilitation, and replacement (OMRR&R) responsibilities in accord with the provisions of the Project Partnership Agreement and the project's operation and maintenance (O&M) manual. Local agencies are responsible for providing funding for O&M, which is often underfunded as a result of underestimating the O&M costs that were computed early in project development. Today, local agencies have difficulty funding O&M, as well as capital projects because agency funding has not kept pace with flood risk management needs.

Deer Creek Debris Basin

Management Action
A specific structural or nonstructural strategy, action, or tactic that contributes to stated goals and addresses identified problems. An example of a nonstructural management action is to "reduce flood damages through acquisitions, easements, and private conservation programs." An example of a structural management action would be the construction of a levee.

Management Actions

Flood management employs structural approaches (e.g., levees, floodwalls) and nonstructural approaches (e.g., flood risk awareness, emergency management). Historically, the approach to flood management has been to develop narrowly focused flood infrastructure projects. This infrastructure altered or confined natural watercourses, which reduced the chance of flooding thereby minimizing damage to lives and property. This traditional approach looked at floodwaters primarily as a potential risk to be mitigated instead of as a natural resource that could provide multiple societal benefits.

A number of flood management actions to reduce flood risk are available to decision makers and flood managers in California. A management action is a specific structural or nonstructural strategy, action, or tactic that contributes to achieving goals and addressing problems. Management actions range from policy or institutional changes to operational and physical changes to flood infrastructure. Management actions provide a toolkit of potential actions that local, State, and Federal agencies can use to address different types of flood hazards and different types of flood risks. These actions differ based on many factors, including geography and type of flooding to address. Approaches have ranged from construction of levees and concrete-lined channel beds to developing forecast-based (forecast-informed) operations of linked systems, to implementation of multibenefit IWM projects. These approaches include the following broad categories:

- Floodplain and reservoir storage and operations
- Flood infrastructure (levees/floodwalls, bypasses, hydraulic structures, debris basins, storm surge barriers)
- Operation and maintenance
- Ecosystem functions
- Floodplain management (floodproofing, easements/acquisitions, risk awareness, insurance)
- Flood preparedness, response, and recovery, including Hazard Mitigation Plans (HMPs)
- Policies and regulations
- Permitting
- Finance and revenue

Sacramento Bypass Weir 2006

For a complete list of Management Actions and more details on specific actions, see *Attachment H: Practicing Flood Management Using an Integrated Water Management Approach*.

Flood Management Regulations

Flood management regulations are typically based on the 100-year, 200-year, or 500-year events in California. FEMA's National Flood Insurance Program (NFIP) bases coverage on 100-year and 500-year events. Senate Bill (SB) 5 requires protection against a 200-year event in urban areas of the California Central Valley.

Two flood events levels* are commonly used for insurance and planning purposes.

500-Year Flood is shorthand for a flood that has a 1-in 500 probability of occurring in any given year. This may also be expressed as the 0.2 percent annual chance flood.

100-Year Flood has a 1-in-100 (or 1 percent) probability of occurring in any given year.

* These levels indicate a percentage of probability and severity. It does not mean that a flood happens only every 100 or 500 years.

The NFIP is administered by FEMA, which offers Federally backed flood insurance to communities that enact and enforce minimum floodplain management regulations. The NFIP offers flood insurance to communities that participate in the program through the adoption of a floodplain management ordinance that regulates development in areas with a high risk of flooding. To purchase flood insurance, a property must be located in a community that participates in the program. As an incentive, the NFIP Community Rating System (CRS) recognizes communities that exceed the minimum floodplain management regulations by reducing flood insurance premiums for the community's property owners. Under the CRS program, flood insurance discounts range from 5 percent to 45 percent, depending on the credit points earned. Points are rewarded for 19 activities under four elements—Public Information, Mapping and Regulations, Flood Damage Reduction Activities, and Warning and Response, as shown in Table C-3.

Table C-3. CRS Activity Credits

Activity	Maximum Possible Points[a]	Maximum Points Earned[b]	Average Points Earned[c]	Percentage of Communities Credited[d]
Public Information				
Elevation Certificate	116	116	46	100
Map Information Service	90	70	63	93
Outreach Projects	350	175	63	90
Hazard Disclosure	80	57	14	68
Flood Protection Information	125	98	33	92
Flood Protection Assistance	110	65	49	41
Flood Insurance Promotion[e]	110	0	0	0
Mapping and Regulations				
Floodplain Mapping	802	585	65	50
Open Space Preservation	2,020	1,548	474	68
Higher Regulatory Standards	2,042	784	214	98
Flood Data Maintenance	222	171	54	87
Stormwater Management	755	540	119	83
Flood Damage Reduction Activities				
Floodplain Management Planning	622	273	123	43
Acquisition and Relocation	1,900	1,701	136	23
Flood Protection	1,600	632	52	11
Drainage System Maintenance	570	449	214	78
Warning and Response				
Flood Warning and Response	395	353	144	37
Levees[f]	235	0	0	0
Dams[f]	160	0	0	0

Notes:
[a]The maximum possible points are based on the 2013 Coordinator's Manual.
[b]The maximum points earned are converted to the 2013 Coordinator's Manual from the highest credits attained by a community as of October 1, 2011. Growth adjustments and new credits for 2012 are not included.
[c]The average points earned are converted to the 2013 Coordinator's Manual, based on communities' credits as of October 1, 2011. Growth adjustments and new credits for 2012 are not included.
[d]The percentage of communities credited is as of October 1, 2011.
[e]Activity 370 (Flood Insurance Promotion) is a new activity in 2012. No community has earned these points.
[f]Activities 620 and 630 were so extensively revised that the old credits cannot be converted to the 2013 Coordinator's Manual.

In California, DWR is working to bring more communities into the CRS program and to improve the standing of communities in the program. Today, most flood-prone communities and all but 1 county in California participate in the NFIP (a total of 523 cities and 57 counties); the only county to not participate is Mariposa. In California, 62 towns/cities and 21 counties participate in the CRS program.

The City of Roseville was the first to reach the highest CRS rating (Class 1). Damaging floods in 1995 spurred Roseville to strengthen and broaden its floodplain management program. Today Roseville earns points for almost all CRS creditable activities. The average discount for a policy premium in the Special Flood Hazard Area (SFHA) is $792. In addition, the City of Sacramento has a CRS rating of Class 4. Table C-4 show the communities that participate in the CRS program, their class, rate, and CRS insurance rate policy savings.

Table C-4. California Communities CRS Participation and Savings

Community ID	Community Name	County	Hydrologic Region	Class	Rate (%)	CRS Insurance Total Savings Per Policy ($)	CRS Insurance Total Savings Per Community ($)
60001	Alameda County	Alameda	San Francisco Bay/San Joaquin River	7	15	110	98,166
65028	Fremont, City of	Alameda	San Francisco Bay	7	15	152	65,246
60012	Pleasanton, City of	Alameda	San Francisco Bay	8	10	44	4,174
60013	San Leandro, City of	Alameda	San Francisco Bay	8	10	111	109,988
65022	Concord, City of	Contra Costa	San Francisco Bay	8	10	115	56,430
60025	Contra Costa County	Contra Costa	San Francisco Bay/San Joaquin River	6	20	224	426,705
60034	Pleasant Hill, City of	Contra Costa	San Francisco Bay	8	10	109	49,757
60035	Richmond, City of	Contra Costa	San Francisco Bay	9	5	39	3,898
60710	San Ramon, City of	Contra Costa	San Francisco Bay	6	20	205	12,275
65070	Walnut Creek, City of	Contra Costa	San Francisco Bay	8	10	105	33,090
65029	Fresno County	Fresno	Tulare Lake/San Joaquin River	6	20	92	139,108
60048	Fresno, City of	Fresno	Tulare Lake	8	10	42	14,133
60075	Kern County	Kern	Tulare Lake	8	10	79	280,238
60090	Lake County	Lake	Sacramento River/North Coast	7	15	132	204,777
60136	Long Beach, City of	Los Angeles	South Coast	7	15	170	679,636
65043	Los Angeles County	Los Angeles	South Coast/South Lahontan	7	15	155	349,693
60137	Los Angeles, City of	Los Angeles	South Coast	7	15	96	769,079
60729	Santa Clarita, City of	Los Angeles	South Coast	8	10	139	100,617
65023	Corte Madera, Town of	Marin	San Francisco Bay	7	15	204	124,273
60178	Novato, City of	Marin	San Francisco Bay	6	20	200	306,565
60195	Monterey County	Monterey	Central Coast	5	25	335	548,422
60202	Salinas, City of	Monterey	Central Coast	7	15	119	31,824
60207	Napa, City of	Napa	San Francisco Bay	6	20	251	326,905
60213	Anaheim, City of	Orange	South Coast	8	10	89	52,903
60218	Fountain Valley, City of	Orange	South Coast	8	10	76	82,992
65034	Huntington Beach, City of	Orange	South Coast	7	15	151	1,072,476
60222	Irvine, City of	Orange	South Coast	8	10	7	1,071
60735	Mission Viejo, City of	Orange	South Coast	8	10	34	2,651
60227	Newport Beach, City of	Orange	South Coast	8	10	90	144,450

Table C-4. California Communities CRS Participation and Savings

Community ID	Community Name	County	Hydrologic Region	Class	Rate (%)	CRS Insurance Total Savings Per Policy ($)	CRS Insurance Total Savings Per Community ($)
60212	Orange County	Orange	South Coast	7	15	90	69,705
60228	Orange, City of	Orange	South Coast	9	5	27	3,365
60231	San Juan Capistrano, City of	Orange	South Coast	9	5	51	23,149
60239	Placer County	Placer	Sacramento River/North Lahontan	5	25	149	80,414
60243	Roseville, City of	Placer	Sacramento River	1	45	263	90,367
60636	Lake Elsinore, City of	Riverside	South Coast	9	5	48	4,877
65074	Moreno Valley, City of	Riverside	South Coast	8	10	72	8,239
60751	Murrieta, City of	Riverside	South Coast	9	5	63	6,047
60257	Palm Springs, City of	Riverside	Colorado River	6	20	121	37,579
60245	Riverside County	Riverside	South Coast/Colorado River	9	5	42	109,081
60262	Sacramento County	Sacramento	Sacramento River/San Joaquin River	4	30	89	1,017,699
60266	Sacramento, City of	Sacramento	Sacramento River	5	25	25	1,153,039
60279	Redlands, City of	San Bernardino	South Coast	9	5	57	23,227
60739	Yucaipa, City of	San Bernardino	South Coast	9	5	54	12,984
60294	Oceanside, City of	San Diego	South Coast	8	10	52	80,331
60702	Poway, City of	San Diego	South Coast	8	10	114	34,530
60284	San Diego County	San Diego	South Coast/Colorado River	7	15	130	213,427
60738	Lathrop, City of	San Joaquin	San Joaquin River	8	10	3	534
60706	Manteca, City of	San Joaquin	San Joaquin River	9	5	6	691
60299	San Joaquin County	San Joaquin	San Joaquin River	6	20	103	409,208
60302	Stockton, City of	San Joaquin	San Joaquin River	8	10	13	48,194
60310	San Luis Obispo, City of	San Luis Obispo	Central Coast	7	15	200	136,940
65019	Burlingame, City of	San Mateo	San Francisco Bay	9	5	77	21,975
60708	East Palo Alto, City of	San Mateo	San Francisco Bay	8	10	121	108,953
60311	San Mateo County	San Mateo	San Francisco Bay	9	5	62	22,902
60331	Santa Barbara County	Santa Barbara	Central Coast	6	20	203	305,303
60339	Cupertino, City of	Santa Clara	San Francisco Bay	8	10	95	7,132
60340	Gilroy, City of	Santa Clara	Central Coast	8	10	149	24,064
60341	Los Altos, City of	Santa Clara	San Francisco Bay	8	10	101	10,579

Table C-4. California Communities CRS Participation and Savings

Community ID	Community Name	County	Hydrologic Region	Class	Rate (%)	CRS Insurance Total Savings Per Policy ($)	CRS Insurance Total Savings Per Community ($)
60344	Milpitas, City of	Santa Clara	San Francisco Bay	6	20	243	467,354
60346	Morgan Hill, City of	Santa Clara	San Francisco Bay	7	15	127	54,629
60347	Mountain View, City of	Santa Clara	San Francisco Bay	8	10	112	52,982
60348	Palo Alto, City of	Santa Clara	San Francisco Bay	7	15	203	741,286
60349	San Jose, City of	Santa Clara	San Francisco Bay	7	15	177	1,320,310
60350	Santa Clara, City of	Santa Clara	San Francisco Bay	8	10	97	97,914
60352	Sunnyvale, City of	Santa Clara	San Francisco Bay	7	15	212	173,356
60355	Santa Cruz, City of	Santa Cruz	Central Coast	7	15	77	104,357
60357	Watsonville, City of	Santa Cruz	Central Coast	7	15	207	189,873
60360	Redding, City of	Shasta	Sacramento River	6	20	119	68,381
60370	Fairfield, City of	Solano	San Francisco Bay	7	15	98	32,862
60631	Solano County	Solano	Sacramento River/San Francisco Bay	7	15	115	59,937
60373	Vacaville, City of	Solano	Sacramento River	8	10	37	51,125
60379	Petaluma, City of	Sonoma	San Francisco Bay	6	20	269	173,668
60395	Live Oak, City of	Sutter	Sacramento River	9	5	20	2,013
60394	Sutter County	Sutter	Sacramento River	6	20	19	92,363
60396	Yuba City, City of	Sutter	Sacramento River	6	20	9	18,869
60400	Tehama, City of	Tehama	Sacramento River	6	20	158	14,694
60401	Trinity County	Trinity	North Coast	9	5	35	3,863
60409	Visalia, City of	Tulare	Tulare Lake	9	5	18	88,732
60421	Simi Valley, City of	Ventura	South Coast	7	15	181	353,101
60413	Ventura County	Ventura	South Coast/Central Coast	6	20	171	252,962
60728	West Sacramento, City of	Yolo	Sacramento River	8	10	3	7,249
60423	Yolo County	Yolo	Sacramento River	8	10	48	64,572
60427	Yuba County	Yuba	Sacramento River	7	15	21	54,682

In 2007, a number of laws regarding flood risk and land use planning were enacted. These laws establish a comprehensive approach to improving flood management by addressing system deficiencies, improving flood risk information, and encouraging links between land use planning and flood management. Many of the requirements established by these laws are applicable only in the Central Valley.

How often does a 100-year (1 percent chance) flood event occur?

Although a 100-year flood sounds remote, over the lifespan of an average 30-year mortgage, a home located within the 100-year floodplain has a 26 percent chance of being inundated. This same home has less than a 1 percent chance of fire damage during the same period. What is more significant is if a house is in a 10-year flood area, it is almost certain to see a 10-year flood (96 percent chance) in the same 30-year mortgage cycle. In many areas the difference in flood heights between a 10-year and a 100-year event is less than 1 foot. The chart below shows flood frequency during a 30-year mortgage.

Flood Frequency Chart

Flood Frequency (years)	Chance of Flooding in any Given Year	Percent Chance of Flooding During a 30-year Mortgage
10	10 out of 100 (10%)	96
50	2 out of 100 (2%)	46
100	1 out of 100 (1 %)	26
500	0.2 out of 100 (0.2%)	6

Source: USACE, 2010

A summary of the legislation is provided below.

- SB 5 (2007-2008), Flood Management, required DWR and the Central Valley Flood Protection Board (CVFPB) to prepare and adopt a Central Valley Flood Protection Plan (CVFPP), which was completed in 2012. The bill also requires cities and counties in the valley to amend general plans and zoning ordinances to incorporate policies reflecting the CVFPP within a specified timeframe following adoption of the CVFPP. By 2015, these cities or counties will be prohibited from entering into a development agreement and from approving any permit, entitlement, or subdivision map unless an urban level of flood protection is provided. ("Urban level of flood protection" is defined as the level of protection necessary to withstand flooding that has a 1-in-200 chance of occurring in any given year.)
- Assembly Bill (AB) 156 (2007-2008), Flood Control, provides DWR and the CVFPB with specific authorizations that would enhance information regarding the status of flood protection in the Central Valley. The bill specifically directs DWR to map areas in the Central Valley at risk of flooding, prepare a status report on the Central Valley State Plan of Flood Control (SPFC), identify flood zones protected by levees, and supply notification about flood risk and flood insurance to property owners in those levee-protected flood zones. The bill also requires DWR to specify system deficiencies and planned rehabilitation, including a cost estimate. Components of this bill apply statewide.

- AB 70 (2007-2008), Flood Liability, provides that a city or county might be responsible for its reasonable share of property damage caused by a flood if the State liability for property damage has increased due to approval of new development within a floodplain after January 1, 2008.
- AB 162 (2007-2008), General Plans, requires annual review of the land use element of general plans for areas subject to flooding, as identified by FEMA or DWR floodplain mapping. The bill also requires the safety element of general plans to provide information on flood hazards. Additionally, AB 162 (2007-2008) requires the conservation element of general plans to identify rivers, creeks, streams, flood corridors, riparian habitat, and land that might accommodate floodwater for purposes of groundwater recharge and stormwater management.

Flood Management Governance

In California, over 1,300 local agencies have responsibility for flood management. A broad spectrum of agencies (more than 40 different types), representing different types of governance, has responsibility for flood management and a variety of local flood infrastructure facilities. These agencies are responsible for overseeing approximately 20,000 miles of levees, 1,500 dams, and 1,000 debris basins. A list of major flood infrastructure is included in each hydrologic region, and a compiled list of statewide flood infrastructure is included in Appendix E. Such widespread responsibility makes statewide coordination, funding, and solutions to flood management difficult. Agency roles and responsibilities can be limited by how the agency was formed, which might include enabling legislation, a charter, a memorandum of understanding with other agencies, or facility ownership. Local agencies are facing an ever-changing regulatory environment, budget reductions due to the prolonged economic downturn, as well as changes in Federal funding. Today, California faces a funding crisis for O&M of existing infrastructure and for new infrastructure to protect its residents, the environment, and the world's ninth largest economy. When local entities are a partner on any Federal project, the sponsor must agree to OMRR&R, which goes beyond the requirements of O&M.

Flood Emergency Planning Efforts

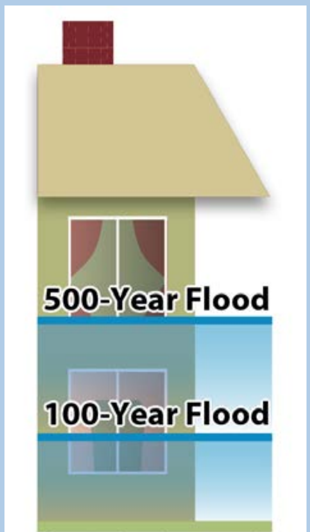
Flood emergency planning efforts include flood emergency preparedness, emergency response, and recovery:

- Flood preparedness is the development of plans and procedures for responding to a flood in advance of a

What would it cost to recover from a major flood event in one of California's urban regions? With many more people and structures per square mile in California's urban areas, California would likely see much higher recovery costs from a major flood than the $110 billion* that has been spent on recovery from Hurricanes Katrina and Rita.

**Congressional Budget Office, 2007*

Any storm can cause flood damage. Large storms, although infrequent, can have disastrous consequences to the entire region.



Slow rise flooding example

flood, including emergency response plans, evacuation procedures, and exercises to assess readiness.

- Emergency response is the aggregate of actions taken by responsible parties at the time of a flood, including early warning of flood events, flood fighting, and emergency sheltering.
- Recovery includes programs and actions to restore utility services and public facilities, repairing flood facilities, draining flooded areas, removing debris, and assisting individuals, businesses, and communities to protect lives and property.

Flood emergency management is a cost-effective tool to reduce flood risk. However, this activity is complex because flood emergency preparedness, response, and recovery responsibilities are often fragmented among local agencies within a region and even within different departments of a single agency, which complicates developing comprehensive plans. Emergency management is important because these programs can be used to inform the public, policymakers, and local agencies how to prepare for and respond to a flood event and can help save lives when a flood event occurs.

Hazard Mitigation Plan

A document that identifies hazards that could affect a community and assesses vulnerability to hazards. The Hazard Mitigation Plan is arrived at through a collaborative process that reaches decisions on how to minimize or eliminate the potential effects of hazards.

Multi-Hazard Mitigation Plans

Multi-Hazard Mitigation Plans (MHMPs) are required by FEMA as a condition of pre- and post-disaster assistance. The Stafford Act, as amended by the Disaster Mitigation Act of 2000, provides for states, tribes, and local governments to undertake a risk-based approach to reducing risks to natural hazards, such as flooding, through mitigation planning. The National Flood Insurance Act of 1968 reinforced the need and requirement for mitigation plans linking flood mitigation assistance programs to local, State, and tribal mitigation plans. For a comprehensive list of FEMA-approved MHMPs along with corresponding dates of approval, refer to Appendix D.

Future of Flood Management

Uncertainties Facing Flood Management

Project development, implementation, and operation constraints have changed as societal values have evolved. Today, all projects, including flood management projects, entail increased stakeholder involvement, land use constraints, changing regulatory requirements, and new environmental considerations. These uncertainties face flood management agencies across the state. [2]

Specific issues impacting flood management projects include the following:

- **Flood management responsibility is fragmented.** Responsibilities for planning, administering, financing, and maintaining flood management facilities and emergency response programs are usually spread among

[2] Because flood management uncertainties are the same statewide, they are discussed only in the statewide overview.

several agencies. More than 1,300 agencies have some responsibility for flood management in the state. Flood management is often spread out within and between these agencies.

- **Projects require extensive stakeholder involvement, which increases project planning costs.** Stakeholders have become more educated about project development and environmental requirements. Successful projects require proper engagement of a diverse set of stakeholders.
- **Population growth** continues to expand in California. As a result, there will be increased pressure to develop within floodplains. This development will limit the options available to flood managers and exacerbate flooding potential.
- **Land use decisions may not adequately prioritize public safety.** Uninformed residents and policymakers can make decisions that put people and property at increased risk. Internal and intra-agency coordination is important when local agencies make development decisions. In some cases, providing adequate space for flood management facilities meeting existing and future needs during the development approval process for an area would reduce flooding impacts. Even with new requirements that require flood management to be incorporated in agency General Plans, flood managers are sometimes not included in development discussions. Improving coordination within and between agencies will potentially improve land use decisions.

Yuba River Flooding

- **Delayed permit approvals and complex permit requirements are obstacles to flood risk reduction.** Many agencies wait years for permits, resulting in poorly maintained projects and missed funding opportunities for new projects. Often, agencies face conflicting or confusing requirements when permitting projects. Also, regulatory requirements to renew existing permits or obtain new permits frequently require extensive mitigation. This mitigation can greatly increase project costs and delay project schedules.
- **Climate change could have a significant impact on precipitation and runoff in California.** Climate change is projected to cause increases in global temperatures that likely will lead to shifts in the timing and magnitude of precipitation and runoff. Increased temperatures might alter precipitation and runoff patterns, such as higher snowline elevations, earlier snowmelt, and less overall snowpack. The projected temporal shift in reservoir inflows could pose significant challenges for management of flood storage capacity in major system reservoirs. This would result in potential increases to the number of people, property, and other assets exposed to flooding in the state.

All of these factors have led to more costly projects due to expanded planning, coordination, and mitigation requirements. Addressing these issues will require a move away from the traditional approach to developing flood management projects. Mitigation components of many projects are already moving flood management toward using an IWM approach. However, a true IWM approach requires coordination, collaboration, and inclusion of a broad set of objectives from the initiation of the project development process.

Evolving Flood Management Practices

Flood management practices today are evolving to using an IWM approach. An IWM approach provides an overall flood management strategy for long-term economic stability, public safety, and enhancement of environmental stewardship. The IWM approach to flood management practices has been slowly evolving due to increased stakeholder involvement, land use constraints, changing regulatory requirements, new environmental constraints, and project mitigation requirements. As agencies move toward this integrated approach to flood management, the number of successful IWM projects will continue to increase.

IWM is a strategic approach that combines specific flood management, water supply, and ecosystem actions to deliver multiple benefits. An IWM approach promotes system flexibility and resiliency to accommodate changing conditions such as regional preferences, ecosystem needs, climate change, flood or drought events, and financing capabilities.

Using an IWM approach creates high-value, multibenefit projects, increases agency coordination and collaboration, and provides access to a broader set of funding sources. IWM reinforces the interrelation of different water management components, such as water supply, flood management, stormwater management, water quality, and environmental stewardship, with the understanding that changes in the management of one component will affect the others. IWM uses a participatory process that applies knowledge from the various water management disciplines, as well as the insights from diverse stakeholders and land management practitioners. Moving toward an IWM approach also will help flood management agencies address the residual flood risk while dealing with future uncertainties such as population growth, climate change, and different economic situations. These future uncertainties coupled with a trend in increasing natural disasters with damages exceeding $1 billion (as shown in Figure C-3) make using IWM an imperative.

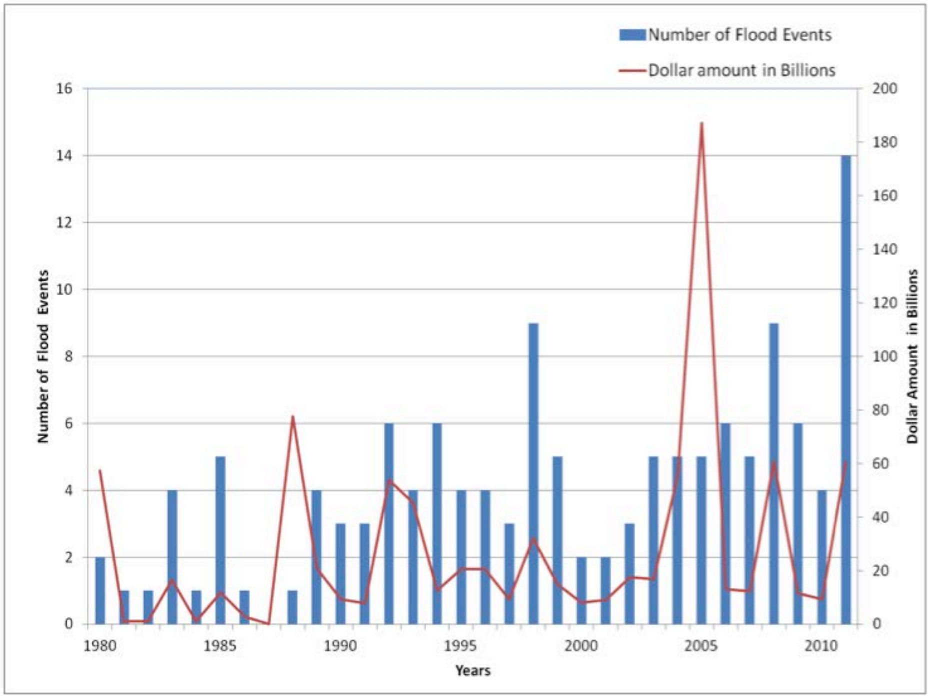


Figure C-3. Nationwide Trend in Billion Dollar Disasters 1980 – 2011

Source: NOAA, 2012

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3.0 Flood History by Hydrologic Region

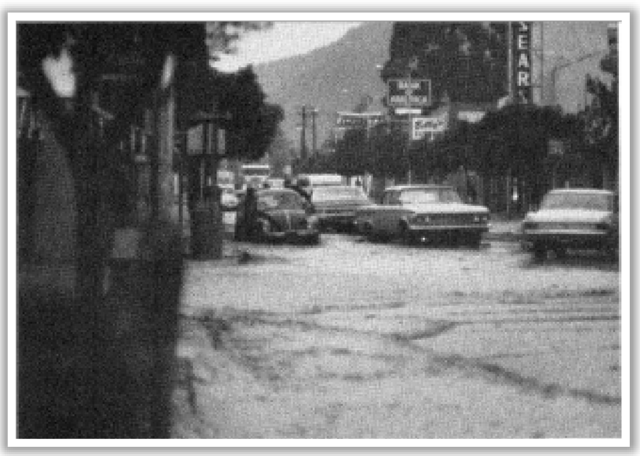
DWR examines hydrologic issues by considering the 10 hydrologic regions. These regions represent the watersheds of principal rivers, or groups of rivers and streams, that are closely related geographically. The following 10 subsections of this report present the flood history of each hydrologic region. The subsections consist of region-specific material, including a brief regional setting, stream descriptions, peak flows, historic floods, history of flood response, and current flood management.

3.1 Central Coast Hydrologic Region

3.1.1 Regional Setting

The Central Coast Hydrologic Region extends from southern San Mateo County in the north to Santa Barbara County in the south. The dominant topographic features are a dramatic 300-mile coastline featuring sea cliffs, bays, coves, and coastal terraces, bordering a region of craggy mountain ridges and stream-cut canyons trending parallel to the coast, punctuated by the broad Monterey, Estero/Morro, and San Luis Obispo bays. River and creek systems within the region drain into the Pacific Ocean. The Salinas River is by far the largest.

In the Central Coast Hydrologic Region, approximately 427,000 people and over $36 billion in assets and 146,300 acres of crops are exposed in the 500-year floodplain. Three hundred sixteen plant and animal species that are State- or Federally listed as threatened, endangered, or rare are exposed to the flood hazards in the region. Table CC-1 provides a snapshot of people, structures, crops, infrastructure, and sensitive species exposed to flood hazards during 100-year and 500-year flood events.



San Luis Obispo Flooding Business Section, 1973

Table CC-1. Central Coast Hydrologic Region Exposures within the 100-Year and 500-Year Floodplains

Segment Exposed	100-year (1%) Floodplain	500-year (0.2%) Floodplain
Population (% total exposed)	92,700 (6%)	426,900 (29%)
Total Depreciated Replacement Value of Exposed Structures and Contents	$10.3 billion	$36.3 billion
Exposed Crop Value	$564.6 million	$689.3 million
Exposed Crops (acres)	123,600	146,300
Tribal Lands (acres)	0	0
Essential Facilities (count)	50	230
High Potential-Loss Facilities (count)	24	32
Lifeline Utilities (count)	23	33
Transportation Facilities (count)	466	624
Department of Defense Facilities (count)	5	5
Plant species State- or Federally listed as Threatened, Endangered, or Rare[a]	202	204
Animal species State- or Federally listed as Threatened, Endangered, or Rare[a]	111	112

Note:
[a]Many Sensitive Species have multiple occurrences throughout the state, and some have very large geographic footprints that may overlap more than one analysis region. As a result, a single Sensitive Species could be counted in more than one analysis region. Because of this, the reported statewide totals will be less than the sum of the individual region reports.

The Central Coast region has a temperate Mediterranean climate characterized by mild, wet winters and warm, dry summers. West of the Coast Range, the climate of the region is dominated by the Pacific Ocean and characterized by small daily and seasonal temperature changes and high relative humidity. As distance from the ocean increases, the maritime influence decreases, resulting in a more continental type of climate that generates warmer summers, colder winters, greater daily and seasonal temperature ranges, and lower relative humidities. Between 2005 and 2008, the average annual precipitation (usually rain) in the region ranged from about 12 to 42 inches. Most of the rain occurs between late November and mid-April. The average annual precipitation near Salinas is about 14 inches; Santa Cruz and Big Sur receive almost double that amount. Average annual precipitation in most of the Santa Cruz Mountain area can exceed 50 inches. The southern interior basins usually receive 5 to 10 inches per year. The mountain areas receive more rainfall than the valley floors.

Dana Street Flooding, San Luis Obispo, January 1969

Figure CC-1 illustrates the location of major features in the region, including streams and rivers.

Stream Descriptions

Table CC-2 includes a description of each watercourse mentioned in connection with the Central Coast Hydrologic Region. The descriptions proceed southward along the coast. Tributaries are listed in upstream order. Carpenter Creek, a tributary of Meadow Creek, is shown in italics and listed in upstream order of its diversion point. Indentation indicates tributary status.

Central Coast Rivers

Figure CC-1 Rivers and Streams of the Central Coast Hydrologic Region

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

Table CC-2. Stream Descriptions, Central Coast Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM SYSTEMS ENTERING THE PACIFIC OCEAN OR A CONNECTED BAY					
1	San Lorenzo River	Santa Cruz Mountains	S		Santa Cruz Harbor
1A	Branciforte Creek	5 mi N of Santa Cruz	S		Santa Cruz
1A1	Carbonera Creek	NW of Scotts Valley	S		Santa Cruz
2	Pajaro River	W of San Felipe Lake	W		Monterey Bay at Watsonville
2A	Salsipuedes Creek	Near Hecker Pass	S		Near Pajaro
2A1	Corralitos Creek	N of Corralitos	SE		N of Pajaro
2B	San Benito River	Near San Benito Mountain	NW		Near Chittenden
2B1	San Juan Canyon	Gabilan Range SE of San Juan Bautista	NW		SE of Chittenden
2B2	Tres Piños Creek	W of Panoche Pass	NW		W of Tres Piños
2C	Uvas Creek (Carnadero Creek)	Loma Prieta	SE, S		Near Sargent
2D	Llagas Creek	Loma Prieta	NE, SE	Lake Chesbro	SE of Gilroy
2D1	Miller Slough	NW of Gilroy	SE		W of Gilroy
2D1a	West Branch Llagas Creek	Between Morgan Hill and Gilroy	SE		NW of Gilroy
2E	Pacheco Creek	W of San Luis Reservoir	W		At San Felipe Lake
3	Salinas River	SE of Santa Margarita	NW		Monterey Bay S of Moss Landing
3A	Arroyo Seco	Ventana Wilderness	NE		Near Soledad
3B	San Lorenzo Creek	Mustang Ridge	NW, SW		King City
3C	San Antonio River	Ventana Wilderness	SE	San Antonio Reservoir	Bradley
3D	Nacimiento River	Ventana Wilderness	SE	Nacimiento Reservoir	Camp Roberts
4	Carmel River	Ventana Wilderness	NW		Carmel Bay S of Carmel-by-the-Sea
5	Palo Colorado Canyon	Ventana Wilderness	NW		S of Rocky Point
6	Big Sur River	Ventana Wilderness	NW		S of Point Sur
7	San Simeon Creek	Santa Lucia Mountains N of Cambria	SW		N of Cambria
8	Villa Creek	Santa Lucia Mountains E of Harmony	S		E of Point Estero
9	Cayucos Creek	Santa Lucia Mountains N of Cayucos	S		Estero Bay at Cayucos

Table CC-2. Stream Descriptions, Central Coast Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM SYSTEMS ENTERING THE PACIFIC OCEAN OR A CONNECTED BAY					
10	Morro Creek	Santa Lucia Mountains SW of Paso Robles	SW		Estero Bay at City of Morro Bay
10A	Little Morro Creek	Santa Lucia Mountains NW of Morro Bay	SW		City of Morro Bay
11	Chorro Creek	Cuesta Ridge	NW		Morro Bay S of City of Morro Bay
12	Los Osos Creek	Irish Hills W of San Luis Obispo	NW		Morro Bay S of City of Morro Bay
13	San Luis Obispo Creek	Santa Lucia Mountains near Mount Lowe	S		San Luis Obispo Bay at Avila Beach
13A	See Canyon Creek	Irish Hills N of Port San Luis	SE		Near Avila Beach
13B	Davenport Creek	N of Edna	W		S of San Luis Obispo
13C	Sycamore Creek	SW slopes of Chumash Peak	SE		S of San Luis Obispo
13C1	Prefumo Creek	Irish Hills W of San Luis Obispo	E		In Laguna Lake
13D	Stenner Creek	Santa Lucia Mountains N of San Luis Obispo	S		San Luis Obispo
13D1	Old Garden Creek	N slope of Cerro San Luis Obispo	N, E, S		NW of Mission San Luis Obispo
13D2	Brizzolara Creek	Santa Lucia Mountains N of San Luis Obispo	S		California Polytechnic State University
14	Arroyo Grande Creek	Santa Lucia Wilderness	SW		Arroyo Grande
14A	Meadow Creek	N of Grover Beach	SW		Grover Beach at the Pacific Ocean
14A1	Carpenter Creek	Grover Beach	W		Pacific Ocean
14B	Corbit Canyon	N of Arroyo Grande	S		Arroyo Grande
14C	Tar Spring Creek	Loma Pelona E of Arroyo Grande	W		Arroyo Grande
15	Santa Maria River	E of Santa Maria	W		W of Guadalupe
15A	Suey Creek	E slope of Temattate Ridge NE of Nipomo	S		NE of Santa Maria
15B	Bradley Creek	SE of Santa Maria	N		E of Santa Maria
15C	Cuyama River	San Emigdio Mountains	NW, S	Twitchell Reservoir	E of Santa Maria
15C1	Huasna River	Garcia Mountain	S	Twitchell Reservoir	Twitchell Reservoir
15D	Sisquoc River	Big Pine Mountain	NW		E of Santa Maria

Table CC-2. Stream Descriptions, Central Coast Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM SYSTEMS ENTERING THE PACIFIC OCEAN OR A CONNECTED BAY					
16	San Antonio Creek[a]	Solomon Hills	W		N of Purisima Point
17	Santa Ynez River	Santa Ynez Mountains N of Carpinteria	E		Surf
17A	Rodeo-San Pasqual Creek	Santa Ynez Mountains SW of Lompoc	N		W of Lompoc
17B	San Miguelito Creek	Sudden Peak	N		Lompoc
17C	Cemetery Creek	E of Vandenberg Village	S		NW of Lompoc
17D	Cebada Creek	Purisima Hills NE of Lompoc	S		NE of Lompoc
17D1	Purisima Creek	Purisima Hills NE of Lompoc	SW		NW of Lompoc
17E	Santa Rita Creek	Purisima Hills NE of Lompoc	SW		E of Lompoc
17E1	Hoag Creek	Purisima Hills NW of Lompoc	S		Santa Rita Valley
17F	Santa Agueda Creek	Figueroa Mountain NE of Santa Ynez	S		Below Lake Cachuma
18	Goleta Slough	NE of Isla Vista	E		Goleta E of University of California
18A	Tecolotito Creek	Santa Ynez Mountains S of Brush Peak	S		W of Santa Barbara Airport in Goleta
18A1	Carneros Creek	Santa Ynez Mountains at Goddard Picnic Ground	S		W of Santa Barbara Airport in Goleta
19	Atascadero Creek	Santa Ynez Mountains NW of Santa Barbara	SW		Goleta Beach County Park
19A	San Pedro Creek	Santa Ynez Mountains at Goddard Picnic Ground	S		N of Goleta Beach County Park
19A1	San Jose Creek	Santa Ynez Mountains SE of Brush Peak	E, S		N of Goleta Beach County Park
19A2	Las Vegas Creek	Santa Ynez Mountains N of Goleta	S		NE of Santa Barbara Airport in Goleta
19A2a	E Branch Las Vegas Creek	Santa Ynez Mountains N of Goleta	S		Goleta
19B	Maria Ygnacio Creek	Crest of the Santa Ynez Mountains	S		S of Goleta
19B1	San Antonio Creek[b]	Crest of the Santa Ynez Mountains	SW		N of Goleta
19C	Hospital Creek	Santa Ynez Mountains N of El Sueno	S		S of Goleta Cemetery
19D	Cieneguitas Creek	Santa Ynez Mountains NW of Santa Barbara	SW		W of Santa Barbara
20	Arroyo Burro	Crest of the Santa Ynez Mountains	S		W of Santa Barbara

Table CC-2. Stream Descriptions, Central Coast Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM SYSTEMS ENTERING THE PACIFIC OCEAN OR A CONNECTED BAY					
21	Mission Creek	Santa Ynez Mountains N of Santa Barbara	S		Santa Barbara
22	Sycamore Creek	Santa Ynez Mountains NE of Santa Barbara	S		Santa Barbara
23	Montecito Creek	Crest of the Santa Ynez Mountains	S		Montecito
24	San Ysidro Creek	Crest of the Santa Ynez Mountains	S		Summerland
24A	Oak Creek	Santa Ynez Mountains N of Montecito	S		Montecito
25	Romero Creek	Santa Ynez Mountains at Romero Saddle	S		Fernald Point at Montecito
26	Arroyo Paredo	Crest of the Santa Ynez Mountains	S		Serena
27	Carpinteria Slough	In El Estero at Carpinteria	E		In El Estero at Carpinteria
27A	Santa Monica Creek	Santa Ynez Mountains	S		Carpinteria at El Estero
27A1	Franklin Creek	Santa Ynez Mountains	S		Carpinteria at El Estero
28	Carpinteria Creek	Crest of the Santa Ynez Mountains	S, SW		Carpinteria
28A	Gobernador Creek	Snowball Mountain	SW		NE of Carpinteria

Key:
E East, easterly, eastern
N North, northerly, northern
S South, southerly, southern
W West, westerly, western

Notes:
[a] N Santa Barbara County
[b] S Santa Barbara County

Peak Flows

Table CC-3 provides peak flow information in the Central Coast Hydrologic Region and shows a correlation between significant flood events and peak flows.

- Major flood events in the Central Coast region occurred in 1914, 1955, 1969, 1955, and 2006.
- Five streams had a peak flow discharge of more than 50,000 cfs.

Table CC-3. Record Flows for Selected Streams, Central Coast Hydrologic Region

Stream	Location	Mean Annual Runoff (taf)	Peak Stage of Record (feet)	Peak Discharge of Record (cfs)	Date of Peak Discharge
San Lorenzo River	At Santa Cruz	94	23.1	30,400	12/23/1955
Pajaro River	At Chittenden	121	33.7	25,100	3/3/1998
San Benito River	At State Highway 156, near Hollister	26	13.5	34,500	3/3/1998
San Benito River	Near Willow Creek School	20	14.6	9,660	3/10/1995
Tres Piños Creek	Near Tres Piños	12	16.0	27,200	3/3/1998
Pacheco Creek	Near Dunneville	24	21.0	12,600	12/23/1955
Salinas River	Near Spreckels	272[b]	30.3	95,000	2/12/1995
Salinas River	Near Bradley	378[b]	23.4	120,000	3/11/1995
Salinas River	At Paso Robles	76	23.8[1]	28,400	3/10/1995
San Lorenzo Creek	Below Bitterwater Creek, near King City	11	16.2	11,500	1/25/1969
San Antonio River	Near Lockwood	78	14.3	23,600	3/10/1995
Nacimiento River	Below Nacimiento Dam, near Bradley	200	10.9	7,340	2/25/1969
Carmel River	Near Carmel	77	20.9	16,000	3/10/1995
Cuyama River	Below Buckhorn Canyon, near Santa Maria	18[b]	14.8	26,200	2/23/1998
Huasna River	Near Arroyo Grande	15	15.9	21,000	1/25/1969
Sisquoc River	Near Garey	38	23.5[a]	33,600	3/1/1983
Santa Ynez River	At Narrows	94	24.2	80,000	1/25/1969
Santa Ynez River	Below Gibraltar Dam, near Santa Barbara	48	25.8	54,200	1/25/1969

Key:
cfs = cubic feet per second
taf = thousand acre-feet

Notes:
[a]Different date than peak discharge
[b]Most recent but less than period of record

The stations included in this table were selected from all USGS gauging stations in the hydrologic region, according to the following criteria:

- The watercourse must be a natural stream with a watershed of at least 100 square miles.
- The station must have a reasonably continuous record of discharge from 1996 to the present.
- The station must be far enough from other stations on the same river to reasonably represent a separate condition.
- Stations in well defined watercourse locations such as deep canyons are omitted, unless particularly important to the overall flood situation.

3.1.2 Historic Floods

Flood damage has been observed in the Central Coast Hydrologic Region since at least 1812. The Central Coast Hydrologic Region receives very little snow, so floodwaters originate primarily from rainstorms. Flooding occurs most frequently in winter and spring. Most streams produce slow rise floods, but the steep terrain can cause flash floods that are intense and of short duration. The east-west-oriented Santa Barbara coast is so situated that storms may tend to persist and remain stationary near the coastline, producing high runoff and causing flash flooding. Such extended precipitation often produces debris flows, particularly after a season of hillside fire damage; the steepness of the streams can increase the sediment size to boulder proportions. Storm surges that coincide with high tides and high runoff can cause coastal flooding in shoreline communities. Communities may be subject to relatively shallow flooding due to stormwater runoff, exacerbated by continuing urbanization. The presence of dams, levees, and other structural facilities occasionally leads to structural failure floods.

Slow rise flooding is overwhelmingly predominant in this region. Debris flows occur in most major storms, particularly when forest fires have damaged vegetation. Tsunamis are infrequent, but they can cause major devastation. Flash floods and coastal flooding also cause damage at times, as well as other types of flooding that occasionally occur. Table CC-4 presents an abridged synopsis of major floods in the region. For a more comprehensive list of flood events in the region, see Appendix B. Selected significant floods are briefly described below.

1861-62: The "Great Flood." Three storms between December 1861 and January 1862, collectively called the Great Flood, produced some of the largest flood discharges ever experienced in Central Coast. These storms changed landscape in Santa Barbara County. In Santa Cruz County, bridges and mills upstream were destroyed, and buildings built on the banks of the river within the city were washed out to sea.

1878. A tsunami in November 1878 drowned one person and destroyed a wharf at Point Sal, destroyed a wharf at Avila, and damaged a wharf at Cayucos.

1896. In December 1896, a tsunami washed away part of the embankment and the main boulevard in Santa Barbara.

February-March 1938. A major flood in the counties throughout Central Coast region. Regional inundation in February and March of 1938 caused damages totaling $1.2 million.

San Lorenzo River Flood, Santa Cruz County, 1938

December 1955-January 1956. Major floods inundated 14,400 acres in the northern portion of the Central Coastal region and caused $16 million in damage.

Flooding in Santa Cruz, 1955

December 1966-January 1967. The Salinas River Basin and Santa Barbara vicinity experienced major flooding. During the December 1966 flood, one life was lost on the Arroyo Seco. USACE estimated that the flood damage in the Salinas River Basin totaled $6,138,000, with an additional $434,000 storm damage loss to conditions of streets.

San Luis Obispo Flooding, 1969

January-February 1969. A series of storms brought widespread damage to central California. Five people lost their lives in Santa Barbara County. One person died in a mudslide, and 12 people drowned in Ventura County. Estimated damage in Ventura County was $43 million. Total damages for just the January flooding event exceeded $4 million in San Luis Obispo..

February-March 1978. Damage to homes and infrastructure occurred in San Luis Obispo County, notably in Corbit Canyon. In Santa Barbara County, erosion and deposition damaged channels and farmland along the Santa Maria River and other streams of the Central Coast region. A flash flood washed away nine buildings, damaged infrastructure, and left debris deposits in Hidden Springs. Damage to roads, bridges, and farmland was extensive throughout the region.

January-April 1982. . In January 1982, 10 people were killed at Love Creek in Santa Cruz County. The most severe flood damage occurred in South Santa Clara County in and around the cities of Morgan Hill and Gilroy.

March 1995. In March 1995, agricultural crop damages along the Pajaro River were estimated at $67 million for the 3,280 acres that were flooded, and urban damages in the unincorporated town of Pajaro were estimated at $28 million. In Santa Barbara County, major flooding occurred in the areas of Goleta, Santa Barbara, and Montecito. .

March 2011. A tsunami damaged Santa Cruz Harbor. Thirteen boats reportedly sank and approximately 100 more were damaged, which accounted to over $25 million in loss. Damages amounted to approximately $1,020,000 in Monterey County. The damage recorded in the Santa Barbara City Harbor was to a crane, bait barge, and several boats.

Santa Cruz Harbor, 2011 Tsunami

Table CC-4. Selected Flood Events, Central Coast Hydrologic Region

Date	Location	Flood Type	Description	County
December 1861-January 1862	Central Coast	Slow Rise, Coastal, Flash	Three storms between December 1861 and January 1862, collectively called the Great Flood, produced some of the largest flood discharges ever experienced in Central Coast. These storms changed landscape in Santa Barbara County. In Santa Cruz County, bridges and mills upstream were destroyed, and buildings built on the banks of the river within the city were washed out to sea.	Santa Barbara, Santa Cruz, Ventura
November 1878	Point Sal, Avila, Cayucos	Tsunami	A tsunami in November 1878 drowned one person and destroyed a wharf at Point Sal, destroyed a wharf at Avila, and damaged a wharf at Cayucos.	San Luis Obispo, Santa Barbara
December 1896	Santa Barbara	Tsunami	In December 1896, a tsunami washed away part of the embankment and main boulevard of Santa Barbara.	Santa Barbara
January 1914	Regionwide	Slow Rise, Alluvial Fan	Portions of Monterey County experienced flood damage during this time. In San Luis Obispo, rail lines, roads, and bridges were washed out. Agricultural lands suffered considerable damage. Santa Barbara experienced heavy flooding and caused widespread damages in both suburban and rural areas	Monterey, San Luis Obispo, Santa Barbara, Ventura
February-March 1938 "Great Flood"	Regionwide	Slow Rise, Flash, Alluvial Fan	During the February-March 1938 major floods, floodwaters extended throughout the area; damages totaled $1.2 million, a considerable sum for the small amount of development in the region at that time	Monterey, San Benito, San Luis Obispo, Santa Barbara, Santa Clara, Santa Cruz, Ventura
December 1955-January 1956 "Christmas Flood"	Regionwide	Slow Rise	The December 1955 flood inundated 14,400 acres in the northern portion of the Central Coastal region and caused $16 million in damage, 80 percent of which was agricultural, residential, and commercial.	San Luis Obispo, Santa Barbara, Santa Clara, Santa Cruz, Ventura
April 1958	Regionwide, Watsonville, Carmel-by-the-Sea, San Lorenzo River	Slow Rise, Alluvial Fan, Debris Flow	The torrential rains of early April 1958 brought flood conditions to numerous counties in California. Floodwater swept through Monterey County as streams in the Salinas and Carmel Valley watersheds overflowed their banks, closed roads, endangered residents, drowned poultry, and damaged homes. Thirteen deaths and $24 million in damages were recorded. In San Luis Obispo County, roads and highways were flooded. Agricultural lands suffered heavy damages. This was a large flooding event, flooding on all rivers of Ventura but especially on the Santa Clara River. Roads, agricultural lands, and bridges were damaged or destroyed in this event.	Monterey, San Benito, San Luis Obispo, Santa Barbara, Santa Cruz, Ventura
January-February 1963	Gilroy, Morgan Hill, Santa Cruz, Soquel, Pajaro, Corralitos, Soquel, Aptos, Guadalupe River, Salsipuedes Creek	Slow Rise, Debris Flow, Flash, Stormwater	Flooding, debris deposits, and damage to public works occurred in Gilroy and Morgan Hill. The San Lorenzo River and Soquel Creek overflowed, causing major damage in Soquel and flooding in Felton and Gold Gulch.	Monterey, Santa Clara, Santa Cruz, Ventura
March 1964	Avila, Capitola, Cayucos, Morro Bay, Moss Landing, Oceano, Oxnard, Pacific Grove, Rio del Mar, San Simeon, Santa Barbara, Santa Cruz, Ventura	Tsunami	A tsunami was observed all along the California coast, including 14 stations in the region. The California Department of Conservation listed damages at $100,000 at Santa Cruz, $10,000 at Monterey. Most damage was to boats. Minor damage was sustained at Morro Bay and Santa Barbara.	Monterey, San Luis Obispo, Santa Barbara, Santa Cruz

Table CC-4. Selected Flood Events, Central Coast Hydrologic Region

Date	Location	Flood Type	Description	County
November 1964-January 1965	Cold Springs, Hot Springs, Montecito, San Antonio streams, and San Ysidro Creek	Debris Flow, Flash, Slow Rise	In Santa Barbara County, 12 homes were washed away. Six bridges were lost in the Mission Creek area. In Carpentaria, Franklin Creek overflowed and flooded several homes. In Goleta, San Pedro Creek overflowed and flooded developed areas. In Santa Maria, Bradbury Channel was damaged by erosion. Damage to public and private property was in the millions of dollars, and hundreds were forced to evacuate their homes.	Santa Barbara
December 1966-January 1967	Salinas River, Mission Creek, Cienguitas Creek, Little Llagas Creek, Llagas Creek, Gilroy, Uvas Creek, Carnadero,	Slow Rise, Stormwater, Alluvial Fan, Flash	The antecedent moisture conditions, along with the characteristics and intensity of the December 1966 storm caused near-record peak flows on many streams in the Central Coastal area. Major flooding was experienced in the Salinas River Basin and Santa Barbara vicinity. During the December 1966 flood, one life was lost on the Arroyo Seco. USACE estimated that the flood damage in the Salinas River Basin totaled $6,138,000, with an additional $434,000 storm damage loss to conditions of streets.	Monterey, San Benito, San Luis Obispo, Santa Barbara, Santa Clara, Santa Cruz, Ventura
January-February 1969 "The Great Floods of 1969"	Regionwide	Slow Rise, Flash, Stormwater	Five people lost their lives in Santa Barbara County. Several creeks overflowed, hundreds of people were evacuated from their homes, and some homes were completely destroyed. $5 million in damages. One person died in a mudslide, and 12 people drowned in Ventura. Sewer and water supply lines were washed out, posing a health risk to residents. The cost of the 1969 flood for Ventura County was estimated at $43 million. Total damages for just the January flooding event exceeded $4 million in San Luis Obispo.	Monterey, San Benito, San Luis Obispo, Santa Barbara, Santa Clara, Ventura
January 1970	Salinas River Basin, Santa Ynez River	Flash, Slow Rise	The 1970 floods were caused by a series of Pacific storms that brought severe, widespread damage to the Central Coast and the rest of California. Damage was most severe in the Salinas River Basin, in the Santa Ynez River Group, and in the Carpinteria-Montecito area.	Monterey, San Benito, San Luis Obispo, Santa Barbara, Santa Clara, Santa Cruz, Ventura
January-February 1973	Regionwide	Debris Flow, Coastal, Flash, Slow Rise	Severe flooding in February of 1973 along the Central Coast area resulted in road and agricultural land damage. This flood caused $13.6 million in damages, mostly along Stenner Creek, Brizziolari Creek, Prefumo Creek, and See Canyon Creek. Homes, businesses, roads, bridges, rail lines and agricultural lands were destroyed. Many people had to be evacuated	Monterey, San Benito, San Luis Obispo, Santa Barbara, Santa Clara, Santa Cruz, Ventura
January 1978	Llegas Creek, Little Llegas Creek	Slow Rise	Llegas Creek overtopped its banks and flooded surrounding areas.	Santa Clara
February 1980 "Winter Storms"	Regionwide	Slow Rise	Severe winter storm waves threatened to undermine facilities at the Santa Barbara Yacht Club. Storms caused severe flooding, mudslides, and high tides throughout the County. Uvas Creek damaged crops and washed out a bridge crossing in Santa Clara. Floodwaters in Llagas Creek overtopped banks and flooded houses.	Monterey, San Benito, San Luis Obispo, Santa Barbara, Santa Clara, Santa Cruz, Ventura
January-April 1982	Santa Clara, Santa Cruz	Slow Rise, Debris Flow, Structure Failure	The most severe flood damage occurred in South Santa Clara County in and around the cities of Morgan Hill and Gilroy. In Santa Cruz, 10 people were killed at Love Creek. Creek.	Santa Clara

Table CC-4. Selected Flood Events, Central Coast Hydrologic Region

Date	Location	Flood Type	Description	County
November 1982-March 1983	Regionwide	Slow Rise, Stormwater	Heavy rains, high winds, flooding, levee breaks. Declared Federal 2/9/83. Total damages $523,617,032. As a result of the 1982–1983 El Niño events, approximately 20 to 40 feet of the marine terraces by Scenic Drive in Carmel fell into the sea.	Monterey, San Benito, San Luis Obispo, Santa Barbara, Santa Clara, Santa Cruz, Ventura
February 1986 "St. Valentine's Day Storm"	Pajaro River Watershed, Boulder Creek, Gilroy, Uvas Creek, Jones Creek, Llagas Creek, Tennant Creek, Corralitos Creek	Debris Flow, Coastal, Slow Rise, Flash, Alluvial Fan	Significant flooding on the Pajaro River in February 1986. A mudslide destroyed a home and killed a resident in Boulder Creek in Santa Cruz. Overbanking from Uvas Creek in the south caused significant damage to homes in the city of Gilroy in Santa Clara.	Monterey, San Benito, Santa Clara, Santa Cruz
March 1995	Regionwide	Slow Rise, Debris Flow, Stormwater, Structure Failure	In March 1995, agricultural crop damages along the Pajaro River were estimated at $67 million for the 3,280 acres that were flooded, and urban damages in the unincorporated town of Pajaro were estimated at $28 million.	San Benito, San Luis Obispo, Santa Barbara, Santa Clara, Santa Cruz, Ventura
December 1996-January 1997	Guadalupe River, Llagas Creek, Coyote Creek	Slow Rise	Precipitation in the Sierra Nevada mountain range produced an above-normal snowpack and saturated soils. Over 23,000 homes and businesses, agricultural lands, bridges, and roads were damaged	Monterey, San Luis Obispo, Santa Barbara, San Benito, Santa Clara
February 1998	Coastal Communities, Pajar	Flash, Stormwater, Engineered Structure Failure, Slow Rise	Levee break near Santa Maria on Santa Maria River. Two California Highway Patrol officers traveling on Highway 66 were washed away with the road and drowned. Damage to agricultural lands was high. Pajaro's entire population of 3,500 was ordered to evacuate after the levee along the Pajaro River was breached in several places.	Monterey, San Benito, San Luis Obispo, Santa Barbara, Santa Clara, Santa Cruz, Ventura
January 2001	San Luis Obispo	Coastal	An extremely large swell, combined with extremely high tides produced heavy surf and flooding of coastal areas along Central and Southern California.	San Luis Obispo
February 2010	Pismo, Santa Barbara, Morro Bay, Coastline	Tsunami	Large tidal fluctuations in Pismo and Santa Barbara, with strong currents at harbor entrances, significant erosion along the coast, damage to docks, boats, harbor infrastructure, and minor flooding. Events caused approximately $3 million in damages statewide. Strong surges continued into the evening in Morro Bay.	Monterey, Santa Cruz, Santa Barbara, Ventura
March 2011	Santa Cruz, Moss Landing, Morro Bay, Santa Barbara, Santa Barbara Harbor	Tsunami	Tsunami waves struck the California coast, with maximum regional amplitude of 6.6 feet at Port San Luis. Majority of damage in Santa Cruz County occurred at Santa Cruz Harbor. Thirteen boats reportedly sank, and approximately 100 more were damaged. The damages were over $25 million. Damages in Monterey amounted to approximately $1,020,000.	Monterey, San Luis Obispo, Santa Cruz, Santa Barbara, Ventura

3.1.3 History of Flood Response

In the Central Coast Hydrologic Region the major types of flooding include coastal, slow rise, flash, and debris flow flooding. As a result of and in response to the regionally specific flood risks, a number of traditional flood management projects have been developed. These include construction of several reservoirs, channels, levees, and debris basins.

Flood Management Infrastructure

The Central Coast Hydrologic Region is the site of significant flood management infrastructure, including floodwater storage facilities and channel improvements partially funded and/or co-sponsored by State and Federal agencies. Flood management agencies are responsible for operating and maintaining approximately 260 miles of levees, 80 dams, 211 debris basins, and other facilities in the Central Coast Hydrologic Region; however, not all of these are dedicated for flood management or have flood storage.

Central Coast regional flood management projects include the following:

- San Antonio Reservoir on the San Antonio River, a multipurpose reservoir with flood management reservations
- Twitchell Reservoir on the Cuyama River, a multipurpose reservoir with flood management reservations
- A reservoir with small flood reservations on Nacimiento Creek
- Debris basins on Rodeo, San Pasqual, San Miguelito, Franklin, and Santa Monica creeks
- Diversions for Arroyo Grande Creek, Bradley Creek, and Cemetery Creek
- Levees on the San Lorenzo, Pajaro, and Santa Maria Rivers and Corralitos, Salsipuedes, Uvas, Bradley, Franklin and Santa Monica creeks
- Floodwalls on the San Antonio River
- Channel improvements on the San Lorenzo and Santa Maria rivers; on Branciforte, Llagas, West Branch Llagas, Arroyo Grande, Bradley, Rodeo, San Pasqual, San Miguelito, Purisima, Cebada, Franklin, and Santa Monica creeks; and on Miller Slough
- Check structures on Hoag and Santa Rita creeks

For a list of major infrastructure, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*. Flood infrastructure maps for each county are provided in *Attachment D: Summary of Exposure and Infrastructure by County (Mapbook)*.

Flood Management Governance

Although the primary responsibility for flood management might be assigned to a specific local entity in the Central Coast Hydrologic Region, aggregate responsibilities are spread among more than 75 agencies with many different governance structures. Some of the larger agencies in the Central Coast Hydrologic Region include the following:

- Monterey County Water Resources Agency
- San Benito Water District

- San Luis Obispo Flood Control and Water Conservation District
- Santa Barbara Flood Control and Water Conservation Agency
- Santa Cruz Flood Control and Water Conservation District

For a comprehensive list of the entities that have responsibilities or involvement in flood and water resources management, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

Flood-Related Regulations

Several agencies within the region have implemented regulations that directly impact flooding and flood management. For example, Santa Barbara County adopted a flood hazard zoning ordinance and uses building permits and subdivision restrictions to control development in flood-prone areas. Monterey County has a floodplain zoning ordinance and subdivision review process. San Luis Obispo County's ordinance defines zones of flood hazard and closely regulates building in flood-prone areas. Santa Cruz County has building codes and an attendant permit system regulating development in flood hazard areas. San Benito County regulates development in floodways via a county zoning ordinance and building permit process. Local land use jurisdictions have adopted floodplain management ordinances, identifying 100-year floodplains and floodways to qualify for participation in FEMA's NFIP.

Santa Maria Levee Breach, 1988

Flood Emergency Planning Efforts

Emergency management is a significant concern in the Central Coast Hydrologic Region due to the risk of tsunamis and coastal flooding.

Multi-Hazard Mitigation Plans. FEMA-approved MHMPs were identified or collected for Monterey, San Luis Obispo, Santa Barbara, Santa Clara, Santa Cruz, and Ventura counties. For a complete list of FEMA-approved MHMPs with corresponding dates of approval, refer to Appendix D. Other risk assessment studies were prepared by various entities, including USACE, FEMA, and the State Reclamation Board of California. For a comprehensive list of risk assessment studies, refer to *Attachment G: Risk Information Inventory*.

Flood Insurance. FEMA has provided FIRMs for all areas within the region. FIRMs in seven of the region's nine counties were prepared after 2005, and two more were updated in 2010. In the Central Coast Hydrologic Region the counties of Monterey, Santa Barbara, Ventura, and the cities of Salinas, San Luis Obispo, Gilroy, Santa Cruz, and Watsonville participate in the CRS program.

3.1.4 Current Flood Management

In the Central Coast Hydrologic Region, 47 local and USACE flood management projects or planned improvements were identified. Thirty-one of these projects have costs totaling approximately $784 million. In this region, 30 projects that use an IWM approach with a flood component were identified. The projects have an estimated total cost of $420 million. An example of a project using an IWM approach is the Lower Llagas Creek Flood Protection and Creek Capacity Restoration Project. It is a restoration project to address reduced channel capacity in a leveed system. For a comprehensive list of projects, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

In addition, DWR administers the IRWM Grant Program. This program has supported the development of the six IRWM Plans that include parts of the Central Coast Hydrologic Region, four of which acknowledge the critical role of flood management. These four plans include:

- *San Luis Obispo County IRWM Plan*, adopted in 2005, identifies flood control as one of five key goals.
- *Monterey Peninsula, Carmel Bay, and South Monterey Bay IRWM Plan*, 2007, identifies three flood control projects, one on each of the Pajaro, Salinas, and Carmel rivers.
- *Santa Barbara County IRWM Plan*, 2007, mentions flood-control projects that have been implemented at the Carpinteria Salt Marsh (Santa Barbara County Water Resources, 2007).
- *Pajaro River Watershed IRWM Plan*, established in 2007, states that the Pajaro River Flood Prevention Authority, a joint powers authority with representatives from eight agencies in five counties, is active in the watershed (Pajaro Valley Water Management Agency et al., 2007).

Mason and State Street Bridges, Downstream View (Construction of Reach 1A, Phase 1), 2012

3.2 Colorado River Hydrologic Region

3.2.1 Regional Setting

The Colorado River Hydrologic Region is bounded on the north by desert ranges and on the west by the San Gabriel, San Jacinto, Santa Rosa, Volcan, and Laguna mountains and the Tecate Divide. On the south, the region is bounded by the international border with Mexico, and on the east by the states of Arizona and Nevada. The Colorado River Hydrologic Region contains desert bounded by the Colorado River along the Arizona border. Bordering mountains on the west are of moderate height, and the desert floor features isolated mountain ranges in the north and large valleys and plains in the south. Dominant features are the Mojave and Colorado deserts, the Colorado River, Death Valley, and the Salton Sea. The sparse runoff of the region drains into the Colorado River, the Salton Sea, or playas, with only negligible amounts entering or leaving Nevada.

White Pelicans on the Salton Sea

More than 227,000 people and over $20 billion in assets are exposed to a 500-year flood event in the Colorado River Hydrologic Region. Over 185 plant and animal species that are State- or Federally listed as threatened, endangered or rare are exposed to flood hazards distributed throughout the region. Table CR-1 provides a snapshot of people, structures, crop value, and infrastructure, exposed to flooding in the region.

Table CR-1. Colorado River Hydrologic Region Exposures within the 100-Year and 500-Year Floodplains

Segment Exposed	100-year (1%) Floodplain	500-year (0.2%) Floodplain
Population (% total exposed)	31,400 (5%)	227,100 (38%)
Total Depreciated Replacement Value of Exposed Structures and Contents	$2.5 billion	$20.6 billion
Exposed Crop Value	$146.1 million	$275.7 million
Exposed Crops (acres)	49,000	79,100
Tribal Lands (acres)	29,154	57,499
Essential Facilities (count)	20	113
High Potential-Loss Facilities (count)	10	15
Lifeline Utilities (count)	9	22
Transportation Facilities (count)	141	221
Department of Defense Facilities (count)	4	4
Plant species State- or Federally listed as Threatened, Endangered, or Rare[a]	78	85
Animal species State- or Federally listed as Threatened, Endangered, or Rare[a]	99	101

Note:
[a]Many Sensitive Species have multiple occurrences throughout the state, and some have very large geographic footprints that may overlap more than one analysis region. As a result, a single Sensitive Species could be counted in more than one analysis region. Because of this, the reported statewide totals will be less than the sum of the individual regions.

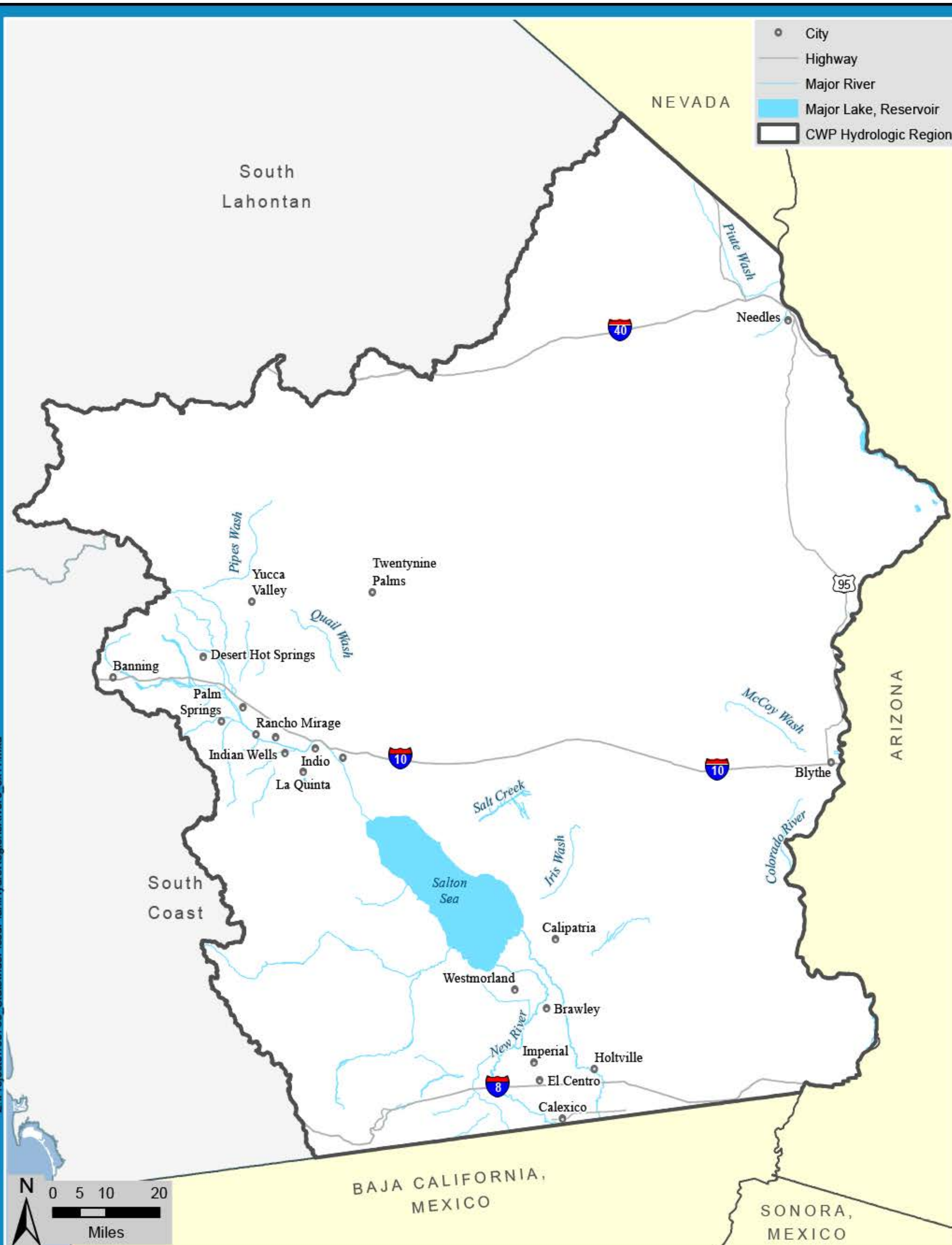
Major streams in the Colorado River Hydrologic Region are the Colorado, Alamo, New, and Whitewater rivers. Most other streams are intermittent or normally dry. Storms are infrequent, but high intensities can be produced by summer thunderstorms or remnants of Pacific cyclones. Flash floods are the predominant cause of damage in the region. These may also include debris flows. Slow rise flooding may occur on the larger streams. Stormwater floods have been recorded, and structure failures happen occasionally. Figure CR-1 illustrates the location of major features in the region, including streams and rivers.

Flash Flooding near Cabazon in Riverside County, 1969

Most of the Colorado River region has a subtropical desert climate with hot summers and short, mild winters. The mountain ranges on the northern and western borders, in particular the San Bernardino and San Jacinto mountains, create a rainshadow effect for most of the region. Annual rainfall amounts range from a little over 6 inches to less than 3 inches. Most of the precipitation for the region occurs in the winter and spring; however, monsoonal thunderstorms, spawned by the movement of subtropical air from the south, can occur in the summer, which can generate significant rainfall in some years. Higher annual rainfall amounts and milder summer temperatures occur in the mountains to the north and west. Clear and sunny conditions typically prevail, and the region receives 85 to 90 percent of the maximum possible sunshine each year, the highest value in the United States.

Stream Descriptions

Table CR-2 includes a detailed description of each watercourse in the Colorado River Hydrologic Region. The descriptions begin with the Colorado River, continue with the Salton Sea, and then proceed from north to south based on location of the river system's sink. Tributaries are described upstream along the Colorado River and clockwise from the Whitewater River around the Salton Sea. Other sinks have one described tributary. Indentation, sub-letters, and numbers indicate tributary status.



Colorado River Rivers

Figure CR-1 Rivers and Streams of the Colorado River Hydrologic Region

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

Table CR-2. Stream Descriptions, Colorado River Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
COLORADO RIVER STREAM SYSTEM					
1	Colorado River	La Poudre Pass, Colorado	SW	Lake Mead, Lake Powell	Gulf of California, Mexico
1A	Palo Verde Lagoon	Blythe and vicinity	SW		Near Palo Verde
1B	McCoy Wash	NW of Blythe	SE		Drainage channels in Blythe
1C	Piute Wash	S of Searchlight, Nevada	S		N of Needles
1D	"S" Street Wash	Needles	E		E Needles
1D1	Sidewinder Wash	Needles	E		Needles
STREAM SYSTEMS TRIBUTARY TO THE SALTON SEA					
2	Whitewater River	SE slopes of San Gorgonio Mountain	SE		S of Mecca
2A	Deep Canyon Stormwater Channel	Near Palm Desert	E		Indian Wells
2A1	Dead Indian Creek	W of Palm Desert	NE		Palm Desert
2A2	Deep Canyon	Santa Rosa Mountain	N		Palm Desert
2B	Morongo Wash	Desert Hot Springs	SE		Palm Desert
2B1	Long Canyon Wash	S of Yucca Valley	S		N of Palm Springs
2B1a	West Wide Canyon	N of Sky Valley	SE	Wide Canyon Reservoir	N of South Palm Springs
2B2	Little Morongo Creek	Onyx Peak	E, S		Desert Hot Springs
2B3	Big Morongo Wash	Onyx Peak	SE		Desert Hot Springs
2C	Magnesia Spring Canyon	W of Rancho Mirage	NE		Rancho Mirage
2C1	West Magnesia Canyon	W of Rancho Mirage	SE		Rancho Mirage
2D	Palm Canyon Wash	Santa Rosa Summit	S, E		Palm Springs
2D1	Tahquitz Creek	NE of Idyllwild	NE		Palm Springs
2D1a	Tahchevah Creek	W of Palm Springs	E	Tahchevah Creek Detention Basin	Palm Springs
2E	Chino Canyon	Near top of Palm Springs Aerial Tramway	NE		Palm Springs
2F	Mission Creek	Ten Thousand Foot Ridge	SE, S		N of Palm Springs
2G	San Gorgonio River	SW slope of San Gorgonio Mountain	SW, E		E of Banning

Table CR-2. Stream Descriptions, Colorado River Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
3	Salt Creek	Orocopia and Chocolate Mountains	SW		Salt Creek Beach
4	Iris Wash	Chocolate Mountains	SW		W of Niland
5	Alamo River	Mexicali Valley, Mexico	W, N		SW of Niland
STREAM SYSTEMS TRIBUTARY TO THE SALTON SEA					
5A	Mammoth Wash	Chocolate Mountains	SW		S of Calipatria
6	New River	Near Cerro Prieto, Mexico	N		NW of Westmorland
6A	Westside Main Canal	All-American Canal	N		Near Brawley
6A1	Coyote Wash	Coyote Mountains	NE		W of El Centro
6A1a	Myer Creek	Jacumba Mountains	NE		Ocotillo
6A2	Yuha Wash	SE of Coyote Wells	E		SE of El Centro
6A3	Pinto Wash	SE of Boulder Park	E		W of Calexico
7	San Felipe Creek	Volcan Mountains N of Whispering Pines	E		SE of Salton City
7A	Carrizo Creek	S of Jacumba in Mexico	N		S of Salton City
8	Palm Wash	W of Salton City	E, NE		Salton City
STREAM TRIBUTARY TO EMERSON LAKE					
9	Pipes Wash	NW of Yucca Valley	E, N		N of Yucca Valley
STREAM TRIBUTARY TO COYOTE LAKE					
10	Quail Wash	S Joshua Tree National Park	NW, E		S end of Coyote Lake

Key:

E East, easterly, eastern
N North, northerly, northern
S South, southerly, southern
W West, westerly, western

Peak Flows

Table CR-3 provides peak flow information in the Colorado River Hydrologic Region and shows a correlation between significant flood events and peak flows.

- The most recent flood with record peak discharge occurred in 2005 on the Whitewater River.
- The highest peak discharge was recorded in 1983 on the Colorado River.

Table CR-3. Record Flows, Colorado River Hydrologic Region

Stream	Location	Mean Annual Runoff (taf)	Peak Stage of Record (feet)	Peak Discharge of Record (cfs)	Date of Peak Discharge
Colorado River	Below Yuma Main Canal Wasteway, at Yuma, Arizona	681[d]	27.7[a]	31,600	8/19/1983
Colorado River	Below Palo Verde Dam, Arizona-California	5,033[d]	17.9[a]	42,300[c]	6/30/1983
Whitewater River	At Indio	3	15.3[a,c]	29,000[c]	3/2 or 3/3/1938
Whitewater River	At Windy Point, near White Water	80	8.3[a]	5,450	1/11/2005
Palm Canyon Wash	Near Cathedral City	2	9.5[a]	8,280	1/16/1993
Salt Creek	Near Mecca[e]	5	19.4[a,b]	9,900	9/24/1976
Alamo River	Near Niland	616	N/A	4,500	8/17/1977
New River	Near Westmorland	446	N/A	3,000	8/17-8/18/1977

Key:

cfs = cubic feet per second taf = thousand acre-feet

Notes:

[a]Different date than peak discharge
[b]Due to backwater
[c]Outside Period of Record
[d]In 2007
[e]Low-flow gauge only, beginning 1990

The stations included in this table were selected from all USGS gauging stations in the hydrologic region, according to the following criteria:

- The watercourse must be a natural stream with a watershed of at least 100 square miles.
- The station must have a reasonably continuous record of discharge from 1996 to the present.
- The station must be far enough from other stations on the same river to reasonably represent a separate condition.
- Stations in well defined watercourse locations such as deep canyons are omitted, unless particularly important to the overall flood situation.

3.2.2 Historic Floods

Flood damage has been observed in the Colorado River Hydrologic Region since at least 1861. Flash floods, often accompanied by debris flows, are the predominant source of flood damage in the Colorado River Hydrologic Region. Slow rise floods occur mostly on the main rivers. Stormwater floods and structure failures may occur. Table CR-4 presents an abridged synopsis of major floods in the region. For a more comprehensive list of flood events in the region, see Appendix B. Selected significant floods are briefly described below.

1861-62: The "Great Flood." The Mojave River rose 20 feet above average in present-day Oro Grande. Lakes formed in the Mojave Desert. .

February 1905-January 1907 (Salton Sea). The floods of 1905 and 1907 came repeatedly in amounts exceeding all recent history. A break in an irrigation diversion structure caused the Colorado River to flow into the Salton Sea from 1905 to 1907. Imperial County is located in the southeastern corner of California and was organized in the wake of disastrous floods and water-control projects along the Colorado River in 1905 and 1907, which diverted waters into the then-dry Salton Sink and created the Salton Sea.

Salton Sea Flooding, 1905-1907

September 1939. A series of tropical disturbances brought heavy rain in Imperial County. The estimated cost of damages to the irrigation works was set at $110,000. The tail end of a hurricane came inland, leaving behind tropical storms that brought very heavy rains to desert locations of Riverside County. Toward the end of the month, a tropical storm referred to as "El Coronado" moved to the areas and left behind extremely heavy rainfall over Southern California. The desert areas received twice as much rain as they generally see in 2 years. Eastern Coachella Valley was less than 2 feet of water.

November-December 1965. This flooding event took nine lives in Riverside County. Most of the flooding in November was a result of heavy rains along the Whitewater and Santa Ana rivers. Floods along the Whitewater River washed out 22 county roads and caused scour and damage to 13 miles of channel between Cathedral City and the Salton Sea. Approximately 2,000 acres of agricultural lands were flooded, with damages from erosion and silting. Citrus and date groves suffered heavy damages. Acquits Creek washed out many roads and damaged bridge abutments on State Highway 111.

January-February 1969. This was a series of storms that brought extremely heavy precipitation to California. Total cost in damages in San Diego County was $2.7 million. Four people lost their lives in Riverside County. Flood damages in Riverside County amounted to $32 million.

September 1976. California received record rainfall as a result of Tropical Storm Kathleen. Six people drowned in the mud and waters in Ocotillo. Agriculture was disrupted throughout the area. The area covered by the Salton Sea increased. Parts of California were declared a disaster area. Damage estimates ranged from $40 to $160 million. .

August 1977. Tropical Storm Doreen ravaged 300 homes, destroyed portions of Interstate 8, and caused three fatalities and $15 million worth of damage to crops. It produced flooding and damage to residences, businesses, and public property. The flood damaged 60 homes in the Borrego Springs area.

Alluvial Fan Flooding, Riverside County, 1993

January 1993. More than 10 inches of rain fell in western Riverside County, causing flooding that damaged roads, bridges, homes, and businesses. Seven people lost their lives on flooded roads. Clogged and backed-up flood management channels and culverts resulted in flooding. Cabazon was isolated due to San Gorgonio River flooding. Roads and residences in this area were flooded. In Palm Springs and Desert Hot Springs, the Whitewater River swept three cars away. In Imperial County, approximately 650 miles of county-maintained gravel roads were damaged.

September 2003. Damages in Riverside County at Banning and Anza were estimated at $150,000.

Table CR-4. Selected Flood Events, Colorado River Hydrologic Region

Date	Location	Flood Type	Description	County
December 1861-January 1862	Regionwide	Slow Rise	The Mojave River rose 20 feet above average in present-day Oro Grande. Lakes formed in the Mojave Desert.	Imperial, Riverside, San Bernardino, San Diego
February 1905-January 1907 (Salton Sea)	Salton Sink	Slow Rise, Engineered Structure Failure	The floods of 1905 and 1907 came repeatedly in amounts exceeding all recent history.	Imperial
January 1916	Brawley, Santa Ana River, San Jacinto River	Flash, Alluvial Fan	Nine inches of rain fell in the Coachella Valley. The cities of Indio, Coachella, and Mecca were completely inundated. Estimated damages to Riverside County were $851,450.	Imperial, Riverside
February 1927	Loma Linda, City of Palm Springs, Mission Valley, Whitewater River, Mojavo River	Alluvial Fan, Flash, Engineered Structure Failure	In San Bernardino Valley, floodwaters destroyed rail lines, highway bridges, and major roadways. The Whitewater River in Riverside at Coachella breached the levee, and the rail bridge was destroyed. One man drowned while clearing debris. Estimated damages from the flood to Riverside County were $1+ million. San Diego dams overtopped and caused widespread flooding downstream. Estimated damages due to this flood were $117,000.	Riverside, San Bernardino
March 1938	Santa Ana River, San Jacinto/ Batiste Creek, Whitewater River, Timescal Creek, Lytle Creek, Mill Creek, Mojavo River	Flash, Slow Rise, Alluvial Fan	Two people died in Riverside County. Livestock of all sorts were lost to flooding in the Santa Ana River. Estimated damages amounted to nearly $2 million. Twenty-two people died as a direct result of the flood, and there was in excess of $11 million in property loss damages in San Bernardino County.	Riverside, San Bernardino

Table CR-4. Selected Flood Events, Colorado River Hydrologic Region

Date	Location	Flood Type	Description	County
September 1939	Brawley, El Centro, Riverside Desert Areas	Alluvial Fan, Flash	A series of tropical disturbances brought heavy rain in Imperial County. The estimated cost of damages to the irrigation works was set at $110,000. The tail end of a hurricane came inland, leaving behind tropical storms that brought very heavy rains to desert locations of Riverside County. Toward the end of the month, a tropical storm referred to as "El Coronado" moved to the areas and left behind extremely heavy rainfall over Southern California. The desert areas received twice as much rain as they generally see in 2 years.	Imperial, Riverside
November-December 1965	Whitewater River, Santa Ana River, Acquits Creek	Alluvial Fan, Flash, Debris Flow	The flooding took nine lives in Riverside County. Most of the flooding in November was a result of heavy rains along the Whitewater and Santa Ana rivers. Approximately 2,000 acres of agricultural lands were flooded, with damages from erosion and silting.	Riverside
September 1967	Banning	Alluvial Fan, Flash, Stormwater	Homes and an apartment complex in the Banning area experienced some flooding after an intense thunderstorm event. An under-designed storm drain clogged with debris and runoff, resulting in flooding. .	Riverside
January-February 1969	Regionwide	Alluvial Fan, Slow Rise , Debris Flow, Engineered Structure Failure	This was a series of storms that brought extremely heavy precipitation to California. Total cost in damages in San Diego County was $2.7 million. Four people lost their lives in Riverside County. Flood damages in Riverside County amounted to $32 million.	Imperial, Riverside, San Diego
September 1975	Twentynine Palms, Needles	Flash, Debris Flow, Alluvial Fan	Thunderstorms closed highways in San Bernardino County due to washouts, debris flow, and flooding. A 50-mile stretch of State Highway 62 east of Twentynine Palms was washed out by flash floods in the area. U.S. Highway 95 was closed from Needles southward to the Nevada state line. The airport at Twentynine Palms was closed for about 3 hours due to several inches of floodwaters on the runway.	San Bernardino
September 1976	Ocotillo, San Diego County, Imperial County	Flash, Debris Flow	Tropical Storm Kathleen caused catastrophic destruction to Ocotillo. Six people drowned in the mud and waters. Other parts of Imperial County experienced severe flash flooding. Flooding disrupted transportation routes in the city. Agriculture was disrupted throughout the area. The area covered by the Salton Sea increased. Parts of California were declared a disaster area. Damage estimates ranged from $40 to $160 million	Imperial, Riverside, San Bernardino, San Diego

Table CR-4. Selected Flood Events, Colorado River Hydrologic Region

Date	Location	Flood Type	Description	County
August 1977	Regionwide	Flash, Alluvial Fan	Tropical Storm Doreen caused significant damage in the region.	Imperial, Riverside, San Diego
September 1977	Thousand Palms, Bermuda Dunes, Cathedral City, Sky Valley	Alluvial Fan, Flash, Debris Flow, Engineered Structure Failure	A late summer storm brought intense rain to the communities of Thousand Palms, Bermuda Dunes, Cathedral City, and Sky Valley. A dike in the Calle Helena area broke, and 90 homes were flooded. A mobile home park that had already flooded before the break was flooded again, which caused further damages. A landslide plugged the Colorado River Aqueduct with 6 feet of debris in the aqueduct's two 12-foot-wide pipes. At least 143 homes were damaged and 10 others destroyed. Damages were estimated to be $708,000.	Riverside
January-February 1980	Harrison Canyon, Mojave River	Alluvial Fan, Debris Flow	In January and February, four separate storms caused debris flows at Harrison Canyon to fill the basin and overflow, flooding houses below the basin. The cost of this event was estimated at $2.5 million.	Imperial, Riverside, San Bernardino, San Diego
December 1982	Ocotillo	Alluvial Fan, Flash	Heavy rains in eastern San Diego County resulted in massive flooding in Ocotillo. Roads, homes, and businesses were damaged by floodwaters	San Diego
March-May 1983	Lower Colorado River	Slow Rise	Colorado River flooding was a result of rapidly melting record snowfalls in the upper watershed. High volumes of water were released from the Glen Canyon, Hoover, Davis, and Parker dams, which caused flooding to low-lying areas in the Lower Colorado River watershed. Damage occurred to recreational facilities, such as campgrounds, boat docks, and launch sites, as well as the businesses servicing these facilities. Sewage treatment plants were also flooded.	Imperial, San Bernardino
August 1983	Cathedral City, Rancho Mirage	Flash, Alluvial Fan	Tropical Storm Ishmael brought periods of high-intensity rain to Riverside County, especially in the desert regions near Cathedral City and Rancho Mirage. This event caused almost $19 million in damages.	Riverside
September 1990	Beaumont-Banning	Alluvial Fan, Flash	A thunderstorm in the Beaumont-Banning areas dropped 1.77 inches of rain in 45 minutes and caused flooding, which damaged some culverts and roads. At least two homes were flooded with up to a foot of water; debris covered roads, highways, and the yards of homes. Floodwaters surrounded some residential property, and flooded one business in this location.	Riverside

Table CR-4. Selected Flood Events, Colorado River Hydrologic Region

Date	Location	Flood Type	Description	County
January 1993	Whitewater River, San Gorgonio River, Murrieta Creek	Alluvial Fan, Flash	More than 10 inches of rain fell in western Riverside County, causing flooding that damaged roads, bridges, homes, and businesses. Seven people lost their lives on flooded roads. Clogged and backed-up flood management channels and culverts resulted in flooding. Cabazon was isolated due to San Gorgonio River flooding. Roads and residences in this area were flooded. In Palm Springs and Desert Hot Springs, the Whitewater River swept three cars away.	Riverside
January 1995	Salton Sea, Desert Shores, La Jolla, San Diego	Alluvial Fan, Flash	The Salton Sea rose because of heavy rainfall during El Niño conditions. A trailer park at Desert Shores had 134 lots flooded. Water seeped into the underground electrical system and caused power outages. The storms also caused problems with sewage treatment operations. The Salton Sea Beach was submerged. A San Diego woman drowned when her basement flooded. The floods resulted in many millions of dollars in losses	Imperial, Riverside , San Diego
September 2003	Banning, Anza	Flash	Damages estimated were $150,000.	Riverside
January 2005	Riverside County	Alluvial Fan, Flash, Debris Flow	Five days of heavy rains caused widespread rain throughout Southern California. On February 4, 2005, President Bush declared seven counties in Southern California disaster areas, including Riverside County. Runoff was high from this event as the ground was saturated from heavy storms preceding it. Interstate 15 at Temecula was closed due to a landslide and flooding. The Ortega Highway was closed. This event caused street flooding in many locations, as well as general flooding of structures.	Riverside
July 2012	Calipatria, Ocotillo, Holtville	Flash	Rain drenched the Imperial Valley on Monday, shutting down major roads and leaving areas throughout the Valley underwater.	Imperial

3.2.3 History of Flood Response

In the Colorado River Hydrologic Region, the major types of flooding include slow rise, flash, and alluvial fan flooding. As a result of and in response to the regionally specific flood risks, a number of traditional flood management projects have been developed. These include construction of reservoirs, and levee, debris basins, and channel improvements.

Flood Management Infrastructure

The Colorado River Hydrologic Region contains floodwater storage facilities and channel improvements partially funded or co-sponsored by State and Federal agencies. Flood management agencies are responsible for operating and maintaining approximately 1,800 miles of levees, 17 dams, and 10 debris basins within the Colorado River Hydrologic Region; however, not all of these are dedicated for flood management or have flood storage. For a comprehensive list of major infrastructure, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*. Flood infrastructure maps for each county are provided in *Attachment D: Summary of Exposure and Infrastructure by County (Mapbook)*.

Thousand Palms, 2005

Lakes Mead and Powell on the Colorado River provide flood protection for the Colorado River Hydrologic Region from north of Needles to the international border with Mexico near Winterhaven. Other flood protection measures include Wide Canyon Reservoir in West Wide Canyon, a detention basin on Tahchevah Creek, a debris basin, levees, channel improvements, groins, and bank protection.

Flood Management Governance

Although primary responsibility for flood management might be assigned to a specific local entity in the Colorado River Hydrologic Region, aggregate responsibilities are spread among 41 agencies with many different governance structures. Some of the larger agencies in the Colorado River region include the following:

- Imperial County
- Imperial Irrigation District
- Coachella Valley Water District
- Riverside County Flood Control and Water Conservation District
- San Bernardino County Department of Public Works
- San Diego County Flood Control District

For a comprehensive list of the entities that have responsibilities or involvement in flood and water resources management, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

Flood-Related Regulations

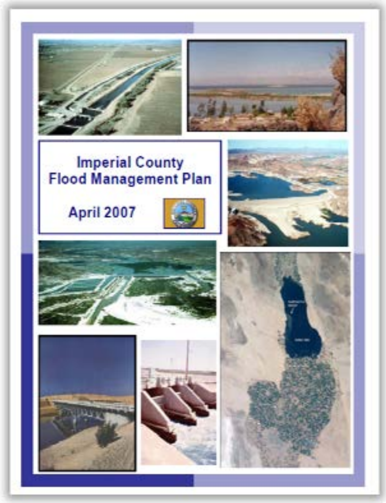
Throughout the region most of the streams with flood control infrastructure have been designated as floodways. Regulated floodways include the San Gorgonio, Whitewater, New, and Alamo rivers; Little Berdo, Lower Berdo, Gilman Home, and Indian Canyon channels; West Pershing, Mission, Tahquitz, and Tahchevah creeks; Lucerne and Rabbit lakes; and Morongo, Palm, Pipes, Airport, S Street, Fox, and

Sidewinder washes. This limits what can be constructed in the floodways for specific design storm events (e.g., 100-year event). Imperial County requires a permit for construction below the negative 220-foot contour near the Salton Sea. The county and three of its incorporated cities also regulate construction on the New and Alamo rivers and El Centro Drain floodplains. Through county ordinances, San Bernardino and Riverside counties both regulate development within floodways. Local land use jurisdictions have adopted floodplain management ordinances, identifying 100-year floodplains and floodways to qualify for participation in FEMA's NFIP.

Flood Emergency Planning Efforts

Emergency management is important because these programs can be used to inform the public, policymakers, and local agencies how to respond to a flood event, which can help save lives when a flood event occurs.

Hazard Mitigation Plans. FEMA-approved MHMPs were identified or collected for Imperial, Riverside, San Bernardino, and San Diego counties. For a list of FEMA-approved MHMPs for entities in the Colorado River region with corresponding dates of approval, refer to Appendix D. Other risk assessment studies were prepared by various entities, including USACE, FEMA, and the State Reclamation Board of California. For a comprehensive list of risk assessment studies, refer to *Attachment G: Risk Information Inventory*.



Imperial County Flood Management Plan, 2007

Flood Insurance. The counties of Riverside and San Diego, as along with the City of Palm Springs participate in the CRS program.

3.2.4 Current Flood Management

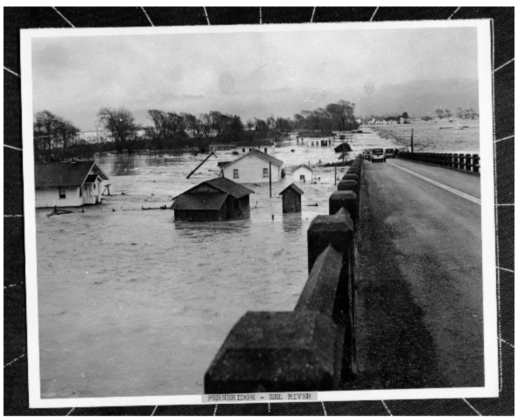
In the Colorado River Hydrologic Region, 25 local and USACE flood management projects or planned improvements were identified. Twenty-one of these projects have estimated costs totaling approximately $70 million. An example of a project utilizing an IWM approach in the Colorado River Hydrologic Region is the Cushenbury Flood Detention Basin. The project is proposed to capture runoff from the San Bernardino Mountains in the Lucerne Valley Sub-basin. Currently, large storm flows in the area drain to dry lakebeds that have low percolation rates. For a comprehensive list of these projects, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

In addition, DWR administers the IRWM Grant Program. This program has supported the development of three IRWM plans in the region—the Anza Borrego Valley IRWM, the Coachella Valley IRWM, and the Imperial IRWM (Borrego Water District, 2009; Coachella Valley Regional Water Management Group, 2010; Imperial Water Forum, 2012). The Imperial IRWM Plan discussed flood management issues in detail.

3.3 North Coast Hydrologic Region

3.3.1 Regional Setting

The North Coast Hydrologic Region encompasses redwood forests, inland mountain valleys, and the semi-desert-like Modoc Plateau. The region consists of Del Norte, Humboldt, Trinity, and Mendocino counties, as well as parts of Siskiyou, Modoc, Lake, Glenn, Sonoma, and Marin counties. The North Coast Hydrologic Region covers roughly 19,500 square miles, and most of the region is mountainous and rugged. The dominant topographic features are the California Coast Range, the Klamath Mountains, and Modoc Plateau. The mountain crests, which form the eastern boundary of the region, are about 6,000 feet in elevation with a few peaks higher than 8,000 feet. All streams in the North Coast Hydrologic Region empty into the Pacific Ocean.



Flooding in Fernbridge, Eel River

Forest and rangeland represent about 98 percent of this region's land area. Much of the region is identified as Federal Bureau of Land Management land, national forests, State or National Parks, and Native American lands (such as the Hoopa Valley and Round Valley reservations). The major land uses in the North Coast region consist of timber production, agriculture, fish and wildlife management, recreational areas, and open space. In recent years, however, timber production has declined.

More than 43,000 people and approximately $4.2 billion in assets are exposed to the 500-year flood event in the region. Three hundred twenty plant and animal species that are State- or Federally listed as threatened, endangered, or rare are exposed to flood hazards in the region. Table NC-1 provides a snapshot of people, structures, crops, infrastructure, and sensitive species exposed to flood hazards in 100-year and 500-year floodplains.

The North Coast Hydrologic Region includes 425 miles of Pacific Ocean coastline from the Oregon border to the Estero de San Antonio watershed. The region then extends east along the Oregon border to include Clear Lake Reservoir and the rest of the Klamath River drainage. Figure NC-1 illustrates the location of major features in the region, including streams and rivers.

Weather conditions in the North Coast region vary greatly between the coastal areas and the arid inland valleys in Siskiyou and Modoc counties. Coastal temperatures are influenced by the Pacific Ocean, and inland areas exhibit a warmer Mediterranean climate. Winter brings heavy rainfall to the Coast Range and, as a result, this region is the most water-abundant area in California. Mean annual runoff is approximately 29 million acre-feet, which is equal to 41 percent of the state's total natural runoff. More than half of the runoff in the North Coast region flows directly into the Pacific Ocean. The North Coast region receives an average of 50 inches of rain, with as much as 100 inches per year along the coast of Del Norte County and as little as 15 inches in

Modoc County. Only a small percentage of the precipitation that falls in the region is in the form of snowfall.

Table NC-1. North Coast Hydrologic Region Exposures within the 100-Year and 500-Year Floodplains

Segment Exposed	100-year (1%) Floodplain	500-year (0.2%) Floodplain
Population (% total exposed)	33,300 (5%)	43,400 (7%)
Total Depreciated Replacement Value of Exposed Structures and Contents	$3.0 billion	$4.2 billion
Exposed Crop Value	$84 million	$87.7 million
Exposed Crops (acres)	108,300	112,200
Tribal Lands (acres)	5,568	5,748
Essential Facilities (count)	45	54
High Potential-Loss Facilities (count)	32	35
Lifeline Utilities (count)	10	13
Transportation Facilities (count)	429	461
Department of Defense Facilities (count)	0	0
Plant species State- or Federally listed as Threatened, Endangered, or Rare[a]	203	203
Animal species State- or Federally listed as Threatened, Endangered, or Rare[a]	117	117

Note:

[a]Many Sensitive Species have multiple occurrences throughout the state, and some have very large geographic footprints that may overlap more than one analysis region. As a result, a single Sensitive Species could be counted in more than one analysis region. Because of this, the reported statewide totals will be less than the sum of the individual regions.

North Coast Rivers

Figure NC-1 Rivers and Streams of the North Coast Hydrologic Region

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

Stream Descriptions

Table NC-2 includes a detailed description of each watercourse in the North Coast Hydrologic Region. The descriptions proceed southward along the coast, with tributaries listed in upstream order. Indentations, sub-letters, and numbers indicate tributary status.

Table NC-2. Stream Descriptions, North Coast Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM SYSTEMS ENTERING THE PACIFIC OCEAN OR A CONNECTED BAY					
1	Smith River	Siskiyou Wilderness	W, S		4 mi. S of Oregon border
1A	Rowdy Creek	Southern Oregon	SW		SW of Smith River
1A1	Dominie Creek	N of Smith River	S		Smith River
2	Klamath River	Upper Klamath Lake, OR	SW, NW		20 mi. S of Crescent City
2A	Turwar Creek	Rattlesnake Mountain	S		Klamath Glen
2B	Trinity River	Scott Mountains	S, W	Clair Engle Lake, Lewiston Lake	Weitchpec
2B1	South Fork Trinity River	Limedyke Mountain	N		Near Salyer
2B1a	Hayfork Creek	Hayfork Divide	W		Hyampom
2B2	Weaver Creek	Weaverville	S		Douglas City
2B2a	East Weaver Creek	Monument Peak	S		Weaverville
2B3	Swift Creek	E slope of Black Mountain in the Trinity Alps	E	Clair Engle Lake	Trinity Center on Clair Engle Lake
2B4	Coffee Creek	E slope of Packers Peak in the Trinity Alps	E		North of Clair Engle Lake
2C	Salmon River	Forks of Salmon	NW		Somes Bar
2D	Scott River	Callahan	NW		Steelhead
2E	Shasta River	NW slopes of Mount Shasta	NW	Lake Shastina	N of Yreka
3	Redwood Creek	Snow Camp Mountain	NW		W of McKinleyville
3A	Prairie Creek	NW corner of Humboldt County	S		N of Orick
3A1	Lost Man Creek	Holter Ridge	W		N of Berry Glenn
4	Mad River	Swim Ridge	NW	Ruth Reservoir	W of McKinleyville
5	Elk River	NE of Rohnerville	NW		Humboldt Bay S of Eureka
5A	Martin Slough	Southern Eureka	SW		S of Pine Hill
6	Eel River	N Lake County, W Glenn County	NW	Lake Pillsbury, Van Arsdale Reservoir	S of Humboldt Bay

Table NC-2. Stream Descriptions, North Coast Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM SYSTEMS ENTERING THE PACIFIC OCEAN OR A CONNECTED BAY					
6A	Salt River	E of Ferndale	W		Near the Pacific Ocean
6B	Rohner Creek	NE of Fortuna	SW		Fortuna
6C	Van Duzen River	Hettenshaw Valley	NW, W		Near Rohnerville
6C1	Yager Creek	Central Humboldt County	W		SW of Carlotta
6C2	Grizzly Creek	Central Humboldt County E of Rio Dell	S		W of Bridgeville
6D	South Fork Eel River	S of Laytonville	N		N of Weott
6D1	Bridge Creek	E of Burlington	S		N of Myers Flat
6E	North Fork Eel River	S of Hettenshaw Valley	S		E of Island Mountain
6F	Middle Fork Eel River	W of Little Buck Rock	S, W		Dos Rios
6F1	Black Butte River	Bear Wallow Ridge	NW		9 mi. E of Covelo
7	Bear River	NE slopes of Rainbow Ridge			3 mi N of Cape Mendocino
8	Mattole River	7 mi SE of Shelter Cove	NW		3 mi. N of Punta Gorda
9	Usal Creek	NE slopes of Jackass Ridge	SE		14 mi N of Westport
10	DeHaven Creek	N of Packard Ridge	W		2 mi N of Westport
11	Wages Creek	S of Packard Ridge	W		1 mi N of Westport
12	Ten Mile River	Both sides of Smith Ridge	SW, W, NW		McKerricher State Park
13	Noyo River	W of Willits	NW		Noyo Harbor
14	Big River	Greenough Ridge	W		Mendocino Bay
15	Navarro River	W of Philo	NW		Near Albion
16	Alder Creek	McAllister Ridge	W		Manchester State Beach
17	Garcia River	W of Yorkville	W, NW		Point Arena
18	Gualala River	Coastal slopes of the Coast Ranges from Anchor Bay to Fort Ross	W, NW, SE		Gualala
19	Russian River	Laughlin Range N of Ukiah	N, W	Lake Mendocino	S of Jenner
19A	Mark West Creek	Diamond Mountain	W		N of Forestville
19A1	Laguna de Santa Rosa	Near Rohnert Park	N		SW of Windsor
19A1a	Santa Rosa Creek	NW of Santa Rosa	SW		W of Santa Rosa
19A1a1	Piner Creek	Santa Rosa	SW		Santa Rosa

Table NC-2. Stream Descriptions, North Coast Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM SYSTEMS ENTERING THE PACIFIC OCEAN OR A CONNECTED BAY					
19A1a1i	Paulin Creek	Santa Rosa	SW	Piner Creek Reservoir	Santa Rosa
19A1a2	Matanzas Creek	East of Rohnert Park	NW	Matanzas Creek Reservoir	Santa Rosa
19A1a2i	Spring Creek	E of Santa Rosa Creek Reservoir	W	Santa Rosa Creek Reservoir	Santa Rosa
19A1a3	Brush Creek	NE of Santa Rosa	S		Santa Rosa
19A1a3i	Middle Fork Brush Creek	NE of Santa Rosa	SW	Middle Fork Brush Creek Reservoir	Santa Rosa
19B	Dry Creek	N of Yorkville	SE	Lake Sonoma	S of Healdsburg
19C	East Fork Russian River	Middle Mountain E of Potter Valley	S, SW	Lake Mendocino	N of Ukiah

Key:
E East, easterly, eastern
N North, northerly, northern
S South, southerly, southern
W West, westerly, western

Peak Flows

Table NC-3 provides peak flow information in the North Coast Hydrologic Region and shows a correlation between significant flood events and peak flows.

- Eel River had the largest peak flow in the state in 1964 Christmas flood. The peak discharge was recorded at 800,000 cfs at Fernbridge.
- North Coast Hydrologic Region had more than five streams with record peak discharge over 100,000 cfs.

Table NC-3. Record Flows for Selected Streams, North Coast Hydrologic Region

Stream	Location	Mean Annual Runoff (taf)	Peak Stage of Record (feet)	Peak Discharge of Record (cfs)	Date of Peak Discharge
Dry Creek	near Geyserville	2,182	15.5	7,600	1/8/1995
Eel River	at Fernbridge	N/A	29.5	800,000	12/23/1964
Eel River	at Fort Seward	3,388	82.6	561,000	12/22/1964
Eel River	at Van Arsdale Dam nr PV	337[b]	34.7[a]	64,100	12/22/1964
Klamath River	near Klamath	12,690[b]	63.0[a,d]	557,000	12/23/1964
Klamath River	at Orleans	5,928	76.5	307,000	12/22/1964
Klamath River	near Seiad Valley	2,807	33.8	165,000	12/23/1964
Klamath River	below Iron Gate Dam	1,500	13.6	29,400	12/22/1964
Mad River	near Arcata	997[b]	30.7	81,000	12/22/1964
Mattole River	near Petrolia	945	36.6	90,400	12/22/1955
Middle Fork Eel R	near Dos Rios	1,146	32.91	135,000	1/1/1997
Navarro River	near Navarro	375	40.6	64,500	12/22/1955
Redwood Creek	at Orick	734	28.2[a]	50,500	12/22/1964
Russian River	near Guerneville	1,663	49.7[a]	102,000	2/18/1986
Russian River	near Healdsburg	1,039	30.0[a]	73,000	1/9/1995
Russian River	near Cloverdale	699	31.6	55,200	12/22/1964
Russian River	near Hopland	515	30.0[d]	45,000	12/22/1955
Salmon River	at Somes Bar	1,304	46.6[c]	133,000[c]	12/22/1964
Scott River	near Fort Jones	463	25.3	54,600	12/22/1964
Shasta River	near Yreka	135	13.9	21,500	12/22/1964
Smith River	near Crescent City	2,720	48.5	228,000	12/22/1964
South Fork Eel River	near Miranda	1,355	46.0	199,000	12/22/1964
South Fork Trinity River	below Hyampom	1,018	33.5[d]	88,000[d]	12/22/1964
Trinity River	at Hoopa	3,568[b]	57.0	231,000	12/22/1964
Trinity River	near Burnt Ranch	1,346[b]	29.8	78,100	12/22/1964
Trinity River	at Lewiston	422	10.4	14,400	1/18/1974
Van Duzen River	near Bridgeville	624	24.0	48,700	12/22/1964

Key:
cfs = cubic feet per second
taf = thousand acre-feet

Notes:
[a]Different date than peak discharge
[b]Most recent but less than period of record
[c]Due to failure of upstream debris dam
[d]Outside period of record
[e] From DWR records

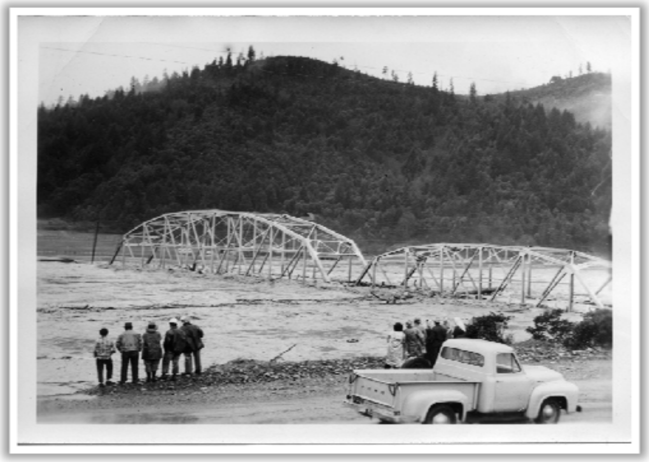
The stations included in this table were selected from USGS gauging stations in the hydrologic region, according to the following criteria:

- The watercourse must be a natural stream with a watershed of at least 100 square miles.
- The station must have a reasonably continuous record of discharge from 1996 to the present.
- The station must be far enough from other stations on the same river to reasonably represent a separate condition.
- Stations in well defined watercourse locations such as deep canyons are omitted, unless particularly important to the overall flood situation.

3.3.2 Historic Floods

Flood damage has been observed in the North Coast Hydrologic Region since at least 1861. Major floods are discussed briefly below. Table NC-4 lists selected floods in the region. Slow rise flooding as a result of heavy rainfall is the primary cause of flooding in the North Coast Hydrologic Region. Flooding due to snowmelt is rare, primarily because of the region's relative warmth in winter, caused by proximity to the Pacific Ocean. Because of land use and the region's steep mountains, rivers may exhibit short lag times and produce flash floods. Extremely high sediment loads contribute to debris flows in the region. High spring tides coupled with intense rainfall can cause flooding to shoreline communities, which is a condition particularly experienced in the Humboldt Bay area. Tsunamis also pose a very real threat, particularly to the community of Crescent City in Del Norte County. Communities in the North Coast region are subject to relatively shallow flooding due to stormwater runoff. A risk of flooding also exists due to failure of dams, levees, or other flood management infrastructure in the region.

Table NC-4 is an abridged table of major floods in the region. For a more comprehensive list of flood events in the region, see Appendix B. Selected significant floods are briefly described below:



Hoopa Flood, 1955-56

1861-62: The "Great Flood." Devastating floods recorded throughout California in the winter of 1861-62 came to be known to historians as the "Great Flood." Flooding in the North Coast Hydrologic Region destroyed Fort Turwar on the Klamath River and washed away bridges in Trinity and Shasta counties.

December 1937. Torrential flooding occurred throughout the region, inflicting heavy losses to roads and bridges in Mendocino County and agricultural development in Humboldt and Lake Counties. The Russian River flooded a resort area in Sonoma County and farmland near Healdsburg.

Crescent City Tsunami, March 1964

December 1955-January 1956. Widespread flooding occurred in communities along the Van Duzen, Eel, Mad, Trinity, and Klamath rivers; damages were estimated to be $36 million and characterized by extremely large flows, including record flows at some locations.

March 1964. The region was struck by a tsunami as a result of the largest earthquake in North American history, measuring 8.4 on the Richter scale, which hit Prince William Sound (south coast of Alaska). The tsunami towered more than 20 feet when it made landfall in the North Coast region. Two hundred eighty-nine homes and businesses were damaged by the big wave; 11 people were killed, and 3 individuals were never found. Damage came to an estimated $11 million.

December 1964-January 1965. A major flood resulted from heavy rainfall that was estimated to be comparable in this region to the rainfall that caused the Great Flood of 1861-62. Twenty-seven State highway bridges and 132 county bridges were destroyed, resulting in the North Coast region being isolated from Scotia to Crescent City. Access to ground transportation was cut off due to highway, railroad, and bridge damages. The Northwestern Pacific Railroad track was twisted and uprooted for 30 miles in the Eel River canyon, and three major bridges were destroyed. Preliminary estimates for the six North Coast region counties in early January 1964 included 24 deaths and 1,653 injuries, along with destruction or damage to 4,784 houses, 374 small businesses, and 800 farm buildings. Twenty-six USGS stream gauges were destroyed. Total damage for the event was estimated to be $175 million.

December 1964 Floods

The Eel River's peak discharge (800,000 cfs) at Fernbridge was greater than the Mississippi River discharge north of St. Louis during the floods of 1993.

January 1974. Major flooding occurred, causing heavy damages, particularly on the upper Klamath and upper Trinity rivers and at Klamath Glen. On the upper Klamath River, numerous highways, roads, and bridges were inundated and damaged by landslides. The Eel River flooding caused major damage on U.S. Highway 101 from Garberville to Cummings and badly damaged county roads. The Northern Pacific Railroad was out of service due to landslides that blocked and damaged the track.

Clear Lake Flooding, 1986

February 1986: St. Valentine's Day Storm. The "St. Valentine's Day Storm" fueled floodwaters from the Klamath, Mad, Eel, and Russian rivers, which washed out highways in many places and isolated residences throughout the region. Coastal flood damages were sustained at Crescent City. The flooding caused major damages to campgrounds and damaged more than 100 redwood trees in Humboldt Redwoods State Park at Weott. A landslide blocked the Eel River at Richardson Grove, flooding campgrounds, and a wave washed away park facilities. Damages were estimated at more than $28 million for the region, with 737 homes and 80 businesses damaged.

March 2011. A tsunami recorded throughout the California coast struck Crescent City Harbor with an 8.1-foot wave, destroying much of the harbor and resulting in one death near Klamath. There was also major damage to docks and boats at Noyo Harbor. Estimated damage in the region was $36 million.

Table NC-4. Selected Flood Events, North Coast Hydrologic Region

Date	Location	Flood Type	Description	County
December 1861-January 1862	Regionwide	Slow Rise, Debris Flow, Coastal	Devastating floods recorded throughout California in the winter of 1861-62 came to be known to historians as the "Great Flood." Flooding in the region destroyed Fort Turwar on the Klamath River and washed away bridges in Trinity and Shasta counties.	Del Norte, Glenn Humboldt, Lake, Marin, Mendocino, Modoc, Siskiyou, Sonoma, Trinity
December 1937	North Coast region	Slow Rise	Torrential flooding occurred throughout the region, causing heavy losses to roads and bridges in Mendocino County and agricultural development in Humboldt and Lake counties. The Russian River flooded a resort area in Sonoma County and farmland near Healdsburg.	Del Norte, Glenn, Humboldt, Lake, Marin, Mendocino, Modoc, Siskiyou, Sonoma, Trinity
April 1946	Arena Cove, Crescent City , Noyo Harbor	Tsunami	Tsunami flooding along the coast. A wave that struck at Crescent City with 3-foot amplitude and a 12-minute period were recorded for this event.	Del Norte, Mendocino
January 1953	Redwood Creek, Smith River	Slow Rise	The Smith River flooded 7,600 acres of farmland. Redwood Creek flooded Orick and severely eroded its banks, undercutting the U.S. Highway 101 bridge. Highway 101 washed out at the Humboldt-Del Norte county line, undercutting a bridge crossing U.S. Highway 101 in Orick. Two deaths were attributed to the flood.	Del Norte, Humboldt
December 1955-January 1956	Del Norte, Lake, Humboldt, Mendocino, Modoc, Sonoma, Siskiyou, Trinity	Slow Rise, Debris Flow	Widespread flooding in communities along the Van Duzen, Eel, Mad, Trinity, and Klamath rivers; damages were estimated to be $36 million and characterized by extremely large flows, including record flows at some locations.	Del Norte, Humboldt, Lake, Mendocino, Modoc, Siskiyou, Sonoma, Trinity
February – April 1958	Regionwide	Slow Rise	Many northern California coastal streams flooded, damaging agricultural lands, roads, and railroads	Del Norte, Glenn, Humboldt, Lake, Marin, Mendocino, Modoc, Siskiyou, Sonoma, Trinity
May 1960	Crescent City	Tsunami	A tsunami was recorded along the full length of the California coast, including five North Coast Stations. At Crescent City Harbor, three persons were injured, boats and a dock were damaged, and city streets were flooded. Docks at Noyo Harbor were severely damaged. Regional damage was estimated at $30,000.	Del Norte
October 1962	Regionwide; Coffee Creek, Mad River, Swift Creek	Debris Flow, Stormwater, Slow Rise, Engineered Structure Failure	Local flooding and landslides. Coffee Creek and Swift Creek rose and damaged their levees. High outflow damaged the Ruth Dam spillway on the Mad River. The Van Duzen River changed course near the Humboldt/Trinity county line and permanently inundated 25 acres.	Del Norte, Glenn, Humboldt, Lake, Marin, Mendocino, Modoc, Siskiyou, Sonoma, Trinity
January-February 1963	Geyserville, Guerneville, Healdsburg, Eel River, Loleta, Ruth Dam	Slow Rise, Engineered Structure Failure	The Scott River damaged infrastructure. High Mad River outflow damaged the spillway at Ruth Dam. The Eel River inundated its delta at Loleta and closed State Highway 211. The Russian River caused flooding and damage to public works in Geyserville and Guerneville. Stormwater closed many roads in Mendocino and Sonoma counties. Dry Creek flooded Healdsburg and lowlands around Santa Rosa.	Humboldt, Lake, Siskiyou, Sonoma, Trinity

Table NC-4. Selected Flood Events, North Coast Hydrologic Region

Date	Location	Flood Type	Description	County
March 1964	Regional coast	Tsunami	The region was struck by a tsunami as a result of the largest earthquake in North American history, measuring 8.4 on the Richter scale, which hit Prince William Sound (south coast of Alaska). The earthquake generated a tsunami that towered more than 20 feet when it made landfall on the North Coast. Two hundred eighty-nine homes and businesses were damaged by the big wave; 10 people were killed, and 3 people were never found. Damage came to an estimated $11 million	Del Norte, Humboldt, Mendocino, Sonoma
December 1964-January 1965	Regionwide	Slow Rise	A major flood resulted from heavy rainfall that was estimated to be comparable in this region to rainfall causing the Great Flood of 1861-62. Twenty seven State highway bridges and 132 county bridges were destroyed, resulting in the North Coast being isolated from Scotia to Crescent City. Access to ground transportation was cut off due to highway, railroad, and bridge damage.	Del Norte Glenn, Humboldt, Lake, Marin, Mendocino, Modoc, Siskiyou, Sonoma, Trinity
January 1968	Eel River, Starvation Flat, Van Duzen River	Slow Rise, Structure Failure	The Eel and Van Duzen rivers flooded lowlands in the Eel River delta. A local levee failed inundating part of Starvation Flat. The Van Duzen River near Bridgeville reached the season's peak stage of 19.3 feet. The flood stage in the Bridgeville area is 17 feet, and flooding occurred in the community of Starvation Flat. Residents of the Starvation Flat area were evacuated by county officials on January 12 and again on January 20 when a second series of storms caused the Van Duzen River to crest at 17.9 feet.	Humboldt, Mendocino, Trinity
November-December 1970	Regionwide	Slow Rise, Stormwater, Debris Flow	The Van Duzen River inundated lowlands at Bridgeville and the Eel overflowed in its delta, depositing silt and debris. Mudslides closed several roads and the railroad was closed for several hours at Pepperwood. Local runoff flooded parts of Ferndale and Eureka. The Russian River overflowed at Guerneville, flooding lowlands and some homes.	Del Norte, Glenn, Humboldt, Lake, Marin, Mendocino, Modoc, Siskiyou, Sonoma, Trinity
January 1974	Regionwide	Slow Rise, Debris Flow, Structure Failure	Major flooding and heavy damage occurred, particularly on the upper Klamath and upper Trinity rivers and at Klamath Glen. On the upper Klamath River, numerous highways, roads, and bridges were inundated and damaged by landslides. The Eel River flooding inflicted major damage on U.S. Highway 101 from Garberville to Cummings and badly damaged county roads. The Northern Pacific Railroad was out of service due to landslides that blocked and damaged the track.	Del Norte, Glenn, Humboldt, Lake, Marin, Mendocino, Modoc, Siskiyou, Sonoma, Trinity
January 1978	Del Norte, Mendocino	Coastal	A combination of high astronomical tides, strong onshore winds, high storm waves, and excessive rainfall produced an aggravated erosional condition in January 1978. A series of storms emanated from a more southern direction than normal, carrying larger amounts of precipitation and wind. These storms, in conjunction with seasonal high tides, generated large destructive storm surges that battered the northern California coastline, damaging many of the better-protected beaches. Jetties and breakwater barriers were overtopped and in some cases undermined.	Del Norte, Mendocino

Table NC-4. Selected Flood Events, North Coast Hydrologic Region

Date	Location	Flood Type	Description	County
December 1982-April 1983	Regionwide	Flash, Debris Flow, Coastal, Stormwater, Slow Rise, Engineered Structure Failure	Tropical Storm Marge caused many small streams to clog with silt and debris and to overflow. Heavy seas damaged coastal structures in the Eureka area, breached the inner jetty at Crescent City and destroyed structures at Point Arena. Mudslides damaged property in Humboldt County, isolated Petrolia, destroyed water supply facilities, clogged streets, and undermined Interstate 5 in Dunsmuir, and washed out State Highway 1 near Jenner and Bodega Bay. A slide dammed the Mattole River and destroyed several homes. Road closures, washouts and inundation were common in the region, including State Highways 36 and 299 in Trinity County, and a mudslide killed one person.	Del Norte, Glenn, Humboldt, Lake, Marin, Mendocino, Modoc, Siskiyou, Sonoma, Trinity
February 1986	Regionwide, Klamath, Mad, Eel, Russian Rivers	Slow Rise	The "St. Valentine's Day Storm" fueled floodwaters from the Klamath, Mad, Eel, and Russian rivers, which washed out highways in many places, isolating residences throughout the region and causing coastal flood damage at Crescent City. Damages were estimated at more than $28 million for the region, with 737 homes and 80 businesses damaged.	Del Norte, Humboldt, Lake, Mendocino, Modoc, Siskiyou, Sonoma, Trinity
January 1995	Del Norte, Sonoma	Slow Rise	Over 50 roads closed, 15,000 residents without power. Total displaced persons exceeded 2,000, of which 456 flood victims were evacuated by air. Thirteen medical cases were treated, and two flood-related fatalities occurred.	Del Norte, Sonoma
December 1996-January 1997	Regionwide	Slow Rise, Debris Flow	Three hundred square miles were flooded, including the Yosemite Valley. A massive tropical storm ravaged the region, damaging residences, the Golden Bears Casino, and in-stream restoration projects. Klamath and Stafford were particularly hard hit. All roads into the region were closed. There was extensive damage to homes, businesses, agriculture, and infrastructure along the Russian River. Over 120,000 people had to be evacuated in northern California. Several levee breaches were reported across the Sacramento and San Joaquin valleys.	Del Norte, Humboldt, Lake, Mendocino, Modoc, Siskiyou, Trinity
December 2005-January 2006	Blue Lake, Eel, Hopland, Klamath River, Navarro, Noyo, Pit, Pudding Creek - Fort Bragg, River, Russian, Susan, West Fork – Calpella, Trinidad River	Slow Rise, Debris Flow, Flash	Flooding closed Interstate 5 near the Oregon border, damaged outdoor recreational facilities in Klamath National Forest, and cut off power to many towns, including Trinidad and Blue Lake. The Laguna de Santa Rosa (Laguna), the largest tributary to the Russian River, experienced heavy flooding, with peak flows on New Year's Day.	Del Norte, Humboldt, Lake, Mendocino, Modoc, Siskiyou, Trinity
March 2011	Crescent City, Noyo Harbor	Tsunami	A tsunami recorded throughout the California coast hit Crescent City Harbor with 8.1-foot amplitude, destroying much of the Harbor and resulting in one death near Klamath. There was also major damage to docks and boats at Noyo Harbor. Estimated damage in the region was $36 million.	Del Norte, Humboldt, Mendocino

3.3.3 History of Flood Response

In the North Coast Hydrologic Region, the major types of flooding include coastal, slow rise, and tsunami. As a result of and in response to the regionally specific flooding, a number of flood management projects have been developed. These include dams on several major rivers in the region, construction of channels and levees, tsunami warnings systems (including sirens, signs, maps), and changes to zoning ordinances.

Flood Management Infrastructure

The North Coast Hydrologic Region has many types of flood management infrastructure, including floodwater storage facilities and channel improvements that were partially funded and/or cosponsored by State and Federal agencies. The North Coast Hydrologic Region has flood management reservoirs, including Lake Mendocino on the East Fork Russian River, Lake Sonoma on Dry Creek, Spring Lake off Santa Rosa Creek, and Matanzas Creek Reservoir on Matanzas Creek. Flood management agencies are responsible for operating and maintaining approximately 1,200 miles of levees, more than 110 dams, and other facilities within the North Coast Hydrologic Region, but not all of these are dedicated for flood management or have flood storage. A small flood management reservoir is on Paulin Creek and another is on Middle Fork Brush Creek; seven other reservoirs provide nondedicated flood retention space. A number of dams, developed for hydropower, and reservoirs, developed for water supply, have either incidental or designed flood capacity. Other flood management projects include levees in the Eel River delta, levees and channel modifications on East Weaver Creek, Redwood Creek, the Klamath River, and the Mad River, as well as channel modifications on Santa Rosa Creek. Measures to mitigate the effects of tsunamis were part of Humboldt Harbor improvements, the Crescent City project, and Crescent City Harbor improvements.

Crescent City Harbor Breakwater, 2012

For a comprehensive list of major infrastructure, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

Flood infrastructure maps for each county are provided in *Attachment D: Summary of Exposure and Infrastructure by County (Mapbook)*.

Flood Management Governance

Although primary responsibility for flood management might be assigned to a specific local entity in the North Coast Hydrologic Region, aggregate responsibilities are spread among more than 100 agencies with many different governance structures. Some of the larger agencies in the North Coast region include the following:

- Del Norte County Flood Control District
- Humboldt County Public Works

- Marin County Flood Control and Water Conservation District
- Mendocino County Water Agency
- Sonoma County Water Agency

For a list of the entities that have responsibilities or involvement in flood and water resources management, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

Flood-Related Regulations

Several agencies in the region have implemented regulations that directly impact flood management and land use within floodplains. For example, Sonoma County has designated the Russian River, Laguna de Santa Rosa, and Mark West Creek as floodways. This limits the construction within the floodways for a specific designed storm event (e.g., 100-year event). Siskiyou County and the towns of Etna and Fort Jones have designated, Scott River, Etna Creek, and Moffett Creek, as floodways via zoning ordinances.

Del Norte County regulates development on the Lower Klamath River's floodplain, and Humboldt County does the same on the Eel River in the vicinity of Fortuna. The Scott Valley Area Plan, adopted as part of the Siskiyou County General Plan, regulates the Scott River floodplain for the 100-year event for appropriate uses, primarily agriculture. Local land use jurisdictions have adopted floodplain management ordinances, identifying 100-year floodplains and floodways to qualify for participation in FEMA's NFIP.

Flood Emergency Planning Efforts

Emergency management is a significant concern within the North Coast Hydrologic Region due the history of tsunamis and other types of flooding. For this reason, dam inundation maps and tsunami management plans have been developed.

Dam Inundation Maps. Several areas around the region have developed dam inundation maps as part of a regional planning process. For example, the Humboldt and Trinity County General Plans have included dam inundation information as part of their General Plans. Specific information has been developed for several dams, including the Matthews Dam on Ruth Lake and the Mad River.

Tsunami Warning Sign, Crescent City, California

Tsunami Management Plans. In 1996, as a response to the tsunami risk in the North Coast region, the Redwood Coast Tsunami Work Group (RCTWG) was formed. The group consists of local, State, and Federal agencies; tribes; and other stakeholders from Mendocino, Humboldt and Del Norte counties. The RCTWG works on a variety of projects, including public education and outreach, evacuation planning and signage, TsunamiReady Program, drills and response planning, and hazard mapping.

Multi-Hazard Mitigation Plans. FEMA-approved MHMPs were identified or collected for Del Norte, Humboldt, Lake, Marin, Mendocino, Siskiyou, and Sonoma counties. For a complete list of entities in the North Coast region that have adopted MHMPs with corresponding dates of FEMA approval, refer to Appendix D. Other risk assessment studies were prepared by various entities, including USACE, FEMA, and the State Reclamation Board of California. For a list of risk studies, refer to *Attachment G: Risk Information Inventory*.

Flood Insurance. FEMA has provided Flood Insurance Rate Maps (FIRMs) for virtually all areas within the region. FIRMs of two of the region's eight counties were prepared after 2005, and five more were updated in 2010. One county had a partial update in 2008. Trinity and Lake counties participate in CRS.

3.3.4 Current Flood Management

In the North Coast Hydrologic Region, 28 local and USACE flood management projects or planned improvements were identified. Fifteen of these projects have costs totaling approximately $260 million. Of these 28 projects, 17 are IWM projects. For a comprehensive list of these projects, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

Salt River Flooding near Ferndale

An example of an IWM project in Humboldt County is the Salt River Restoration Project, which focused on restoring the Salt River channel and riparian floodplain to optimize fish passage, riparian habitat, and sediment transport, as well as restoring tidal wetland and upland areas near confluence of the Salt and Eel rivers, reducing upslope sediment, and controlling erosion in the sub-watersheds. This project is using an adaptive management plan to maintain overall project performance.

In addition, DWR administers the Integrated Regional Water Management (IRWM) Grant Program. This program has supported development of one IRWM plan in the region. The North Coast IRWM Plan discusses flooding primarily in the context of anadromous fisheries and conjunctive use (e.g., enhanced control of polluted floodwaters will improve the quality of surface water and groundwater). The IRWM Plan recommends implementation of two projects with flood control components on the Salt and Big rivers (North Coast Regional Partnership, 2007).

3.4 North Lahontan Hydrologic Region

3.4.1 Regional Setting

The North Lahontan Hydrologic Region consists of the western edge of the Great Basin. The hydrologic region extends from the Oregon border to the southern boundary of the Walker River drainage in Mono County. Much of the region is mountainous high desert, but there are many relatively flat valleys or playas. All streams of the region flow eastward into Nevada or terminate at a lake or one of the playas. The dominant features of the region are high mountain peaks on the west, Surprise Valley, the Honey Lake Basin, and Lake Tahoe. Runoff is in four rivers, two of which are separated into two forks in California, and numerous creeks.

The eastern drainages of the Cascades and the eastern Sierra Nevada north of the Mono Lake drainage, including the California portion of the Lake Tahoe Basin, make up the hydrologic region. The North Lahontan Hydrologic Region contains all of the Susan River, the upper parts of the basins of the Truckee, Carson, and Walker rivers, and the Surprise Valley watershed. These streams have no outlets to the sea and terminate in lakes and playas.

More than 4,000 people and $823 million in assets are exposed to a 500-year flood event in the North Lahontan Hydrologic Region. Table NL-1 provides a snapshot of people, structures, crop value, and infrastructure, exposed to flooding in the region. One hundred fourteen plant and animal species that are State- or Federally listed as threatened, endangered, or rare are exposed to flood hazards distributed throughout the region.

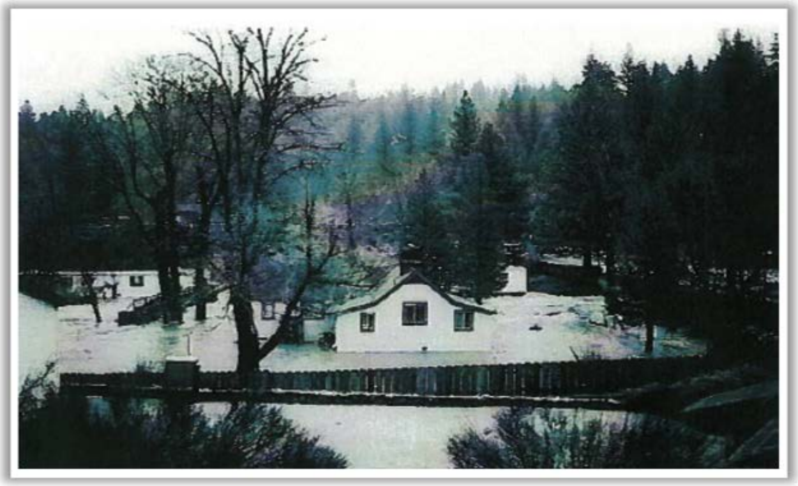
Table NL-1. North Lahontan Hydrologic Region Exposures within the 100-Year and 500-Year Floodplains

Segment Exposed	100-year (1%) Floodplain	500-year (0.2%) Floodplain
Population (% total exposed)	3,600 (4%)	4,000 (4%)
Total Depreciated Replacement Value of Exposed Structures and Contents	$714.2 million	$823.0 million
Exposed Crops Value	$9.9 million	$10.0 million
Exposed Crops (acres)	42,900	143,200
Tribal Lands (acres)	9	14
Essential Facilities (count)	3	3
High Potential-Loss Facilities (count)	9	9
Lifeline Utilities (count)	2	2
Transportation Facilities (count)	70	75
Department of Defense Facilities (count)	1	1
Plant species State- or Federally listed as Threatened, Endangered, or Rare[a]	68	68
Animal species State- or Federally listed as Threatened, Endangered, or Rare[a]	46	46

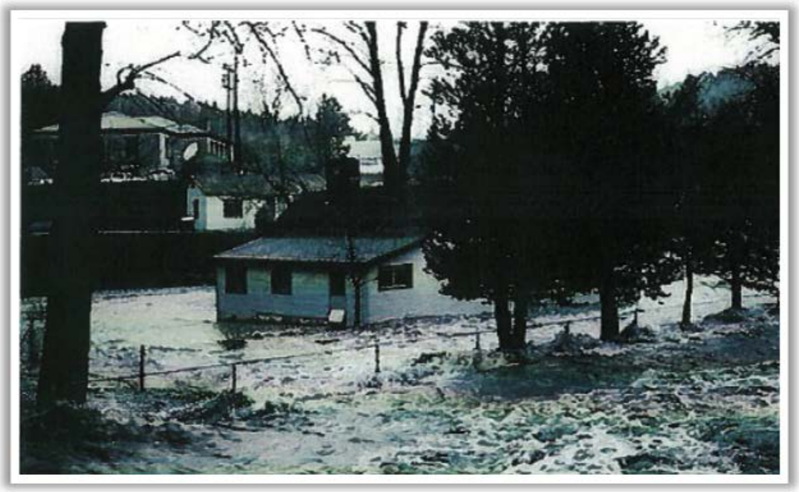
Note:

[a]Many Sensitive Species have multiple occurrences throughout the state, and some have very large geographic footprints that may overlap more than one analysis region. As a result, a single Sensitive Species could be counted in more than one analysis region. Because of this, the reported statewide totals will be less than the sum of the individual regions.

The northern portion of the region is arid, but annual precipitation is high in the Walker Mountains and the Sierra Nevada, where most precipitation falls as snow. Slow rise floods arising from snowmelt or winter rains predominate, although watersheds are steep and runoff may have characteristics of flash floods, including debris flows at times. Summer thundershowers may also bring flash flooding. Stormwater flooding occurs in developed areas. The region does not have a well developed flood protection system, and as a result, riverine flooding often occurs along streams, damaging agricultural and urban properties and causing channel and bank erosion. Figure NL-1 illustrates the location of major features in the region, including streams and rivers.



Markleeville Flooding, 1997



Dry summers with occasional scattered thundershowers characterize the region's climate. Most precipitation falls in late fall and winter. Precipitation is less than 5 inches in the valleys of Eastern Modoc and Lassen counties, about 30 inches in the Walker Mountains, and more than 60 inches in the Sierra Nevada in the upper reaches of the basins of the Truckee, Carson, and Walker rivers. Most of the winter precipitation is snow, which generally accumulates in mountain areas above 5,000 feet. In the valleys, winter precipitation is a mixture of rain and some snow, which usually melts between storms. Snowpack from the eastern slopes of the Sierra Nevada melts in the late spring and summer to become the primary source of surface water supplies for Northern Nevada and for much of California in the region east of the Sierra Nevada.

Stream Descriptions

Table NL-2 provides a detailed description of each watercourse mentioned in connection with the North Lahontan Hydrologic Region. The descriptions proceed from north to south, based on location of the stream system's sink. Tributaries are listed in upstream order. Indentation, sub-letters, and numbers indicate tributary status.

North Lahontan Rivers

Figure NL-1 Rivers and Streams of the North Lahontan Hydrologic Region

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

Table NL-2. Stream Descriptions, North Lahontan Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAMS TRIBUTARY TO **SURPRISE VALLEY**					
1	Bidwell Creek	Warner Mountains at Mount Bidwell	SE		N end of Upper Alkali Lake
2	Mill Creek[b]	Warner Mountains N of Little Baldy	E		Upper Alkali Lake near Lake City
3	Soldier Creek	Warner Mountains at Bald Mountain	NE		S end of Upper Alkali Lake
4	Cedar Creek	Warner Mountains at Payne Peak	E		Middle Alkali Lake E of Cedarville
5	North and South Deep Creek	Warner Mountains S of Payne Peak	E		NW part of Middle Alkali Lake
6	Cottonwood Creek	Warner Mountains at Warren Peak	NE		SW part of Middle Alkali Lake
7	Owl Creek	Warner Mountains S of Warren Peak	NE		Near S end of Middle Alkali Lake
8	Raider Creek	Warner Mountains at Dusenbury Peak	NE		S end of Middle Alkali Lake
9	Eagle Creek	Warner Mountains at Saddleback	NE		N end of Lower Alkali Lake
10	Emerson Creek	Warner Mountains N of Emerson Peak	NE		N end of Lower Alkali Lake
STREAM TRIBUTARY TO HONEY LAKE					
11	Susan River	E of Lassen Volcanic National Park	E		N end of Honey Lake
11A	Willow Creek	Black Mountain E of Eagle Lake	SE		N of Standish
11B	Lassen Creek	N side of Diamond Mountain S of Susanville	NE		Johnstonville
11C	Gold Run Creek	NW side of Diamond Mountain S of Susanville	NE		E of Susanville
STREAM SYSTEM TRIBUTARY TO PYRAMID LAKE, NEVADA					
12	Truckee River	Lake Tahoe	N,NE,N		Pyramid Lake, Nevada
12A	Little Truckee River	SE Sierra County	S	Stampede Reservoir, Boca Reservoir	Boca
12B	Prosser Creek	Castle Peak	E	Prosser Creek Reservoir	W of Boca
12C	Martis Creek	N of Tahoe City	N	Martis Creek Lake[a]	E of Truckee
12D	Cold Creek	Sierra Nevada crest at Mt. Lincoln	NE		W of Truckee
12D1	Donner Creek	Donner Lake	E		E of Donner Lake
12D1a	Negro Canyon	Donner Ridge	S		In Donner Lake
12E	Blackwood Creek	Barker Peak	NE		Lake Tahoe at Tahoe Pines
12F	Upper Truckee River	Near Echo Summit	N		South Lake Tahoe

Table NL-2. Stream Descriptions, North Lahontan Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
12F1	Trout Creek	E El Dorado County	NW		In South Lake Tahoe
STREAM SYSTEM TRIBUTARY TO CARSON SINK, NEVADA					
13	West Fork Carson River	Near Carson Pass	NE, N, NE, E		Carson Sink
14	East Fork Carson River	S Alpine County	N, NE, E		Carson Sink
STREAMS TRIBUTARY TO WALKER LAKE, NEVADA					
15	West Walker River	Sierra Nevada crest near Sonora Pass	N, NE, SE		Walker Lake
15A	Slinkard Creek	Mono/Alpine Co Line SW of Coleville	N, E		N of Topaz Lake
15B	Little Lost Canyon Creek	SW of Walker	NE		N of Walker
15C	Mill Creek[c]				
16	East Walker River	Sierra Nevada crest from Conway Summit to N of Bridgeport	N, NE, N, SE		Walker Lake

Key:

E East, easterly, eastern

N North, northerly, northern

S South, southerly, southern

W West, westerly, western

Note:

[a]Martis Creek Lake currently provides no flood control benefit because of unstable dam foundation conditions.

[b]Modoc County

[c]Mono County

Peak Flows

Table NL-3 provides peak flow information for the North Lahontan Hydrologic Region and shows a correlation between significant flood events and peak flows.

- The most recent peak discharge was recorded in 2005 on Trout Creek.
- The highest peak discharge was recorded on Carson River in 1997.

Table NL-3. Record Flows, North Lahontan Hydrologic Region

Stream	Location	Mean Annual Runoff (taf)	Peak Stage of Record (feet)	Peak Discharge of Record (cfs)	Date of Peak Discharge
Little Truckee River	Below Boca Dam, near Truckee	129[b]	6.1[a]	8,800	12/24/1955
West Fork Carson River	At Woodfords[c]	80	15.4	8,100	1/1/1997
Truckee River	Near Truckee	234	10.0	11,900	1/2/1997
Truckee River	At Tahoe City	165	9.6	2,690	1/2/1997
East Fork Carson River	Below Markleeville Creek, near Markleeville	260	11.8	18,900	1/2/1997
West Walker River	Near Coleville	204	10.2	12,500	1/2/1997
East Walker River	Near Bridgeport	106	6.7	1,910	1/4/1997
Trout Creek	Near Tahoe Valley[c]	26	11.1[a]	615	12/31/2005

Key:

cfs=cubic feet per second

taf=thousand acre-feet

Notes:

[a]Different date than peak discharge

[b]Most recent but less than period of record

[c] Regionally significant site with less than 100 square miles of tributary watershed area

The stations included in this table were selected from all USGS gauging stations in the hydrologic region, according to the following criteria:

- The watercourse must be a natural stream with a watershed of at least 100 square miles.
- The station must have a reasonably continuous record of discharge from 1996 to the present.
- The station must be far enough from other stations on the same river to reasonably represent a separate condition.
- Stations in well defined watercourse locations such as deep canyons are omitted, unless particularly important to the overall flood situation.

3.4.2 Historic Floods

Major floods occur less frequently in the North Lahontan Hydrologic Region compared to the rest of the state. The floods are predominantly of the slow rise type, but streams rise relatively fast because of steep watersheds. Stormwater flooding and occasional flash floods or debris flows may occur. Recordkeeping came late to the North Lahontan region, with stream records beginning around 1900. Flood damage has been observed there since at least 1937. Table NL-4 presents an abridged synopsis of major flood events in the region. For a more comprehensive list of flood events in the region, see Appendix B. Selected significant floods are briefly described below:

1937 Flood, Alpine County

December 1937. The Woodfords-Markleeville highway bridge over that stream was washed away on December 11, 1937. All bridges on the West Fork above Woodfords were either damaged or swept away from Hope Valley. Both banks of Markleeville Creek were flooded. Buildings were flooded, and small buildings were swept away. The total damage was estimated at $150,000 for the entire valley.

January 1997. The Susan River was the primary source of flooding in Lassen County, which sustained $36,670,000 in total damages. Damage to agriculture on the drainages of the Truckee, Walker, and Carson rivers was estimated to exceed $50 million. In Placer County alone, damage estimates for public property were nearly $11 million. Approximately 137 homes and 22 businesses were damaged in the County. Damage from flooding was found in the towns of Mammoth Lakes, Coleville, Walker, and Topaz, Bridgeport. More than 110 homes and 4 businesses were destroyed, totaling at least $25 million in damages. .

East Fork Carson River, 1997

Table NL-4. Selected Flood Events, North Lahontan Hydrologic Region

Date	Location	Flood Type	Description	County
December 1861-January 1862	Regionwide	Slow Rise	The "Great Flood" major flood event occurred throughout the region bringing heavy rainfall and causing significant flooding.	Alpine, El Dorado, Lassen, Modoc, Mono, Nevada, Sierra
December 1937	Carson River, Markleeville Creek	Slow Rise	The Woodfords-Markleeville highway bridge over that stream was washed away on December 11, 1937. All bridges on the West Fork above Woodfords were either damaged or swept away from Hope Valley. Both banks of Markleeville Creek were flooded. Buildings were flooded, and small buildings were swept away. The total damage was estimated at $150,000 for the entire valley	Alpine
November 1950	Alpine, Placer	Flash	Nine deaths were reported statewide. The Woodfords-Markleeville area was flooded.	Alpine, Placer
December 1955 "Christmas Flood"	Regionwide, Feather River, Susan River, Yuba	Slow Rise	Significant and extended heavy rain and wind resulted in flooding throughout coastal and inland regions of northern California. Extensive flooding from overflowing small streams occurred in Placer County suburbs. In Lassen County, there was major flooding in Susanville, Johnstonville, Leavitt Lake, Standish, and Litchfield areas in the Honey Lake Valley. In Alpine County, historic peak flows of West Fork were experienced at Woodfords and East Fork at Gardnerville. High water in Markleeville.	Alpine, El Dorado, Modoc, Nevada, Placer, Sierra
December 1962-February 1963	Bridgeport, Carson River, Donner Lake, Paynesville, Susan River, Topaz, Truckee, Woodfords, Walker	Slow Rise, Stormwater	The floods of 1962-63 caused extensive damage in the Carson River basin. Heavy rain fell at Woodfords. Floodwaters crested on the East Fork of the Carson River at Markleeville. In the Donner Lake area, there was considerable flooding at the northwest comer of Donner Lake caused by water originating in Negro Canyon. Sheet flooding deposited considerable silt and debris.	Alpine, El Dorado, Lassen, Mono, Nevada, Placer, Sierra
December 1964-	Regionwide, Carson River, Susan River,	Slow Rise	Minor flooding and related damages occurred in the North Lahontan area, principally in the Alkali Lakes, Honey Lake, and Truckee and Walker river basins. Flooded areas totaled about 18,000 acres, with damages amounting to $601,000.	Alpine, El Dorado, Lassen, Modoc, Sierra, Nevada, Placer
February 1968	Honey Lake Valley, Susan River, Susanville	Slow Rise	Continuous rain for nearly a week caused extensive flooding in the Honey Lake watershed. The Susan River and storm drains overflowed, inundating roads and stranding travelers in Susanville. Flooding in Honey Lake Valley isolated many ranchers from emergency services.	Lassen
June 1969	Truckee River	Slow Rise	Necessary high releases from Lake Tahoe destroyed several footbridges across the Truckee River. The Granlibakken Bridge was swept downstream, and the River Ranch bridge required emergency cables to prevent its loss.	Alpine, El Dorado, Nevada

Table NL-4. Selected Flood Events, North Lahontan Hydrologic Region

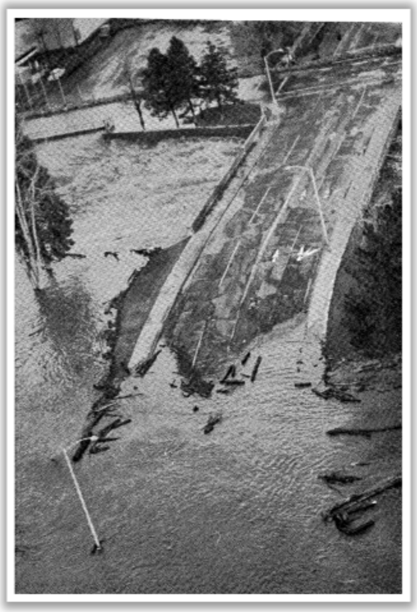
Date	Location	Flood Type	Description	County
February 1986 "St. Valentine's Day Storm"	Regionwide, Honey Lake, Susanville,	Slow Rise, Stormwater	The Susan River overflowed and combined with overloaded storm drains to flood downtown Susanville streets and other roads. Extensive flooding and road damage occurred in Honey Lake Valley.	Alpine, El Dorado, Lassen, Modoc, Mono, Nevada, Placer, Sierra
January 1995	Coleville, Lake Tahoe, Sacramento River Basin, Walker	Slow Rise, Debris Flow	Brought on by El Niño weather conditions, extremely wet conditions coupled with voluminous Sierra runoff led to very high river stages and caused extensive damage to the flood management system.	Alpine, El Dorado, Lassen, Modoc, Mono, Nevada, Placer, Sierra
January 1997	Carson River, East and West Forks of Carson River, South Walker River Basin Fork of the American River, Susan, Truckee, Walker River	Slow Rise, Debris Flow	Carson River flows were approximately four times flood stage, resulting in extensive damage to roadways and irrigation ditches. The West Fork of the Carson River changed course.	Alpine, El Dorado, Lassen, Modoc, Mono, Nevada, Placer, Sierra
December 2005-January 2006	Carson River	Slow Rise, Engineered Structure Failure, Alluvial Fan	Flooding occurred in Placer county by heavy rains and stormwater runoff. Storms impacted transit on public roads and caused some business closures. Flood event on Carson River at East Fork near Markleeville and at Woodfords. Rain-on-snow event.	Alpine, Placer

3.4.3 History of Flood Response

In the North Lahontan Hydrologic Region, the major types of flooding include slow rise, flash, and stormwater flooding. As a result of and in response to the regionally specific flood risks, a number of traditional flood management projects have been developed. These include construction reservoirs and channel improvements.

Flood Management Infrastructure

The North Lahontan Hydrologic Region contains four small floodwater storage facilities and channel improvements that have been partially funded or co-sponsored by State and Federal agencies. Flood management agencies are responsible for operating and maintaining approximately 25 miles of levees, more than 65 dams, and other facilities within the North Lahontan Hydrologic Region; however, not all of these are dedicated for flood management or have flood storage. Reservoirs with flood control capability have been built by USACE, Reclamation, and DWR on Prosser Creek, the Little Truckee River, and Martis Creek.



Truckee River, 1964-65 Flood

The North Lahontan Hydrologic Region contains not only three floodwater storage facilities—Boca Reservoir and Stampede Reservoir on Little Truckee River, and Prosser Creek Reservoir on Prosser Creek—but also an inactive flood management reservoir on Martis Creek and channel improvements on the Truckee River.

For a comprehensive list of major infrastructure, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*. Also, flood infrastructure maps for each county are provided in *Attachment D: Summary of Exposure and Infrastructure by County (Mapbook)*.

Flood Management Governance

Although primary responsibility for flood management might be assigned to a specific local entity in the North Lahontan Hydrologic Region, aggregate responsibilities are spread among 23 agencies with many different governance structures. Most of these agencies are small and, with limited resources, serve a small part of the County. Some of the larger agencies in the region include the following:

- Alpine County
- Lassen County
- Central Modoc Resource Conservation District
- Mono County
- Nevada County
- Placer County Flood Control and Water Conservation District
- Sierra County

For a comprehensive list of the entities that have responsibilities or involvement in flood and water resources management, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

Flood-Related Regulations

Several agencies within the region have implemented regulations that directly impact flooding and flood management. For example, Placer County adopted an ordinance banning building along the Truckee River channel between Tahoe City and Squaw Creek, which USACE describes as subject to inundation. Tahoe Regional Planning Authority has a land use ordinance, including subdivision and grading restrictions prohibiting construction that requires filling or grading wetlands, stream environmental zones, or floodplains. Local land use jurisdictions have adopted floodplain management ordinances, identifying 100-year floodplains and floodways to qualify for participation in FEMA's NFIP.

Flood Emergency Planning Efforts

Emergency management is important because these programs can be used to inform the public, policymakers, and local agencies how to respond to a flood event, which can help save lives when a flood event occurs.

Hazard Mitigation Plans. FEMA-approved MHMPs were identified or collected for Alpine, El Dorado, Lassen, Mono, Nevada, and Placer counties. For a complete list of FEMA-approved MHMPs for the North Lahontan region with corresponding dates of approval, refer to Appendix D. Other risk assessment studies were prepared by various entities, including USACE, FEMA, and the State Reclamation Board of California. For a comprehensive list of risk assessment studies, refer to *Attachment G: Risk Information Inventory*.

Flood Insurance. FEMA has provided FIRMs for all areas within the region. The FIRMs in one of the region's eight counties was updated in 2008. Placer County participates in the CRS program.

3.4.4 Current Flood Management

In the North Lahontan Hydrologic Region, 15 local and USACE flood management projects or planned improvements were identified. Five of these projects have estimated costs totaling approximately $30 million. Five local planned projects, totaling approximately $20 million use an IWM approach to flood management, including the Markleeville Creek Restoration Project, which will reestablish the natural form and function of Markleeville Creek through the site of the former U.S. Forest Service Guard Station. A comprehensive list of identified projects and improvements is provided in *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

In addition, DWR administers the IRWM Grant Program. This program has supported development of the region's only IRWM plan, the Tahoe Sierra IRWM Plan, which acknowledges the critical role of flood management and identifies one flood control project, the Trout Creek Flood Control and Restoration Project (Tahoe Resource Conservation District, 2007). Phase 1 of the project was completed in 2005, and Phase 2 will be implemented in the near future.

3.5 Sacramento River Hydrologic Region

3.5.1 Regional Setting

The Sacramento River Hydrologic Region includes the entire drainage area of the Sacramento River, the state's largest river and its tributaries. The Sacramento River Hydrologic Region extends from Chipps Island in Solano County north to Goose Lake in Modoc County. The region is bounded by the Sierra Nevada on the east, the Coast Range on the west, the Cascade and Trinity Mountains on the north, and the Delta on the south. The Sacramento River basin actually begins in Oregon, north of Goose Lake, a near-sink that intercepts the Pit River drainage at the California-Oregon border. Major lakes and reservoirs in the Sacramento River Hydrologic Region include Goose Lake, Shasta Lake, Clear Lake, Lake Amador, Lake Oroville, Lake Berryessa, and Folsom Lake. Major streams and rivers include the Sacramento, American, Bear, Yuba, Feather, and Pit rivers. Major cities include Sacramento, Yuba City, Oroville, Chico, Marysville, and Redding.

More than 900,000 people and over $66 billion in assets are exposed to the 500-year flood event in the Sacramento River Hydrologic Region. Three hundred forty-seven plant and animal species that are State- or Federally listed as threatened, endangered, or rare are exposed to flood hazards in the Sacramento region. Table SR-1 provides a snapshot of people, structures, crops, and infrastructure exposed to flooding in the region.

Table SR-1. Sacramento River Hydrologic Region Exposures within the 100-Year and 500-Year Floodplains

Segment Exposed	100-year (1%) Floodplain	500-year (0.2%) Floodplain
Population (% total exposed)	200,200 (8%)	925,800 (36%)
Total Depreciated Replacement Value of Exposed Structures and Contents	$16.7 billion	$66.3 billion
Exposed Crop Value	$1.1 billion	$1.7 billion
Exposed Crops (acres)	896,900	1,200,000
Tribal Lands (acres)	2,747	2,833
Essential Facilities (count)	135	510
High Potential-Loss Facilities (count)	108	147
Lifeline Utilities (count)	25	53
Transportation Facilities (count)	1,087	1,620
Department of Defense Facilities (count)	5	6
Plant species State- or Federally listed as Threatened, Endangered, or Rare[a]	203	205
Animal species State or Federally listed as Threatened, Endangered, or Rare[a]	142	142

Note:

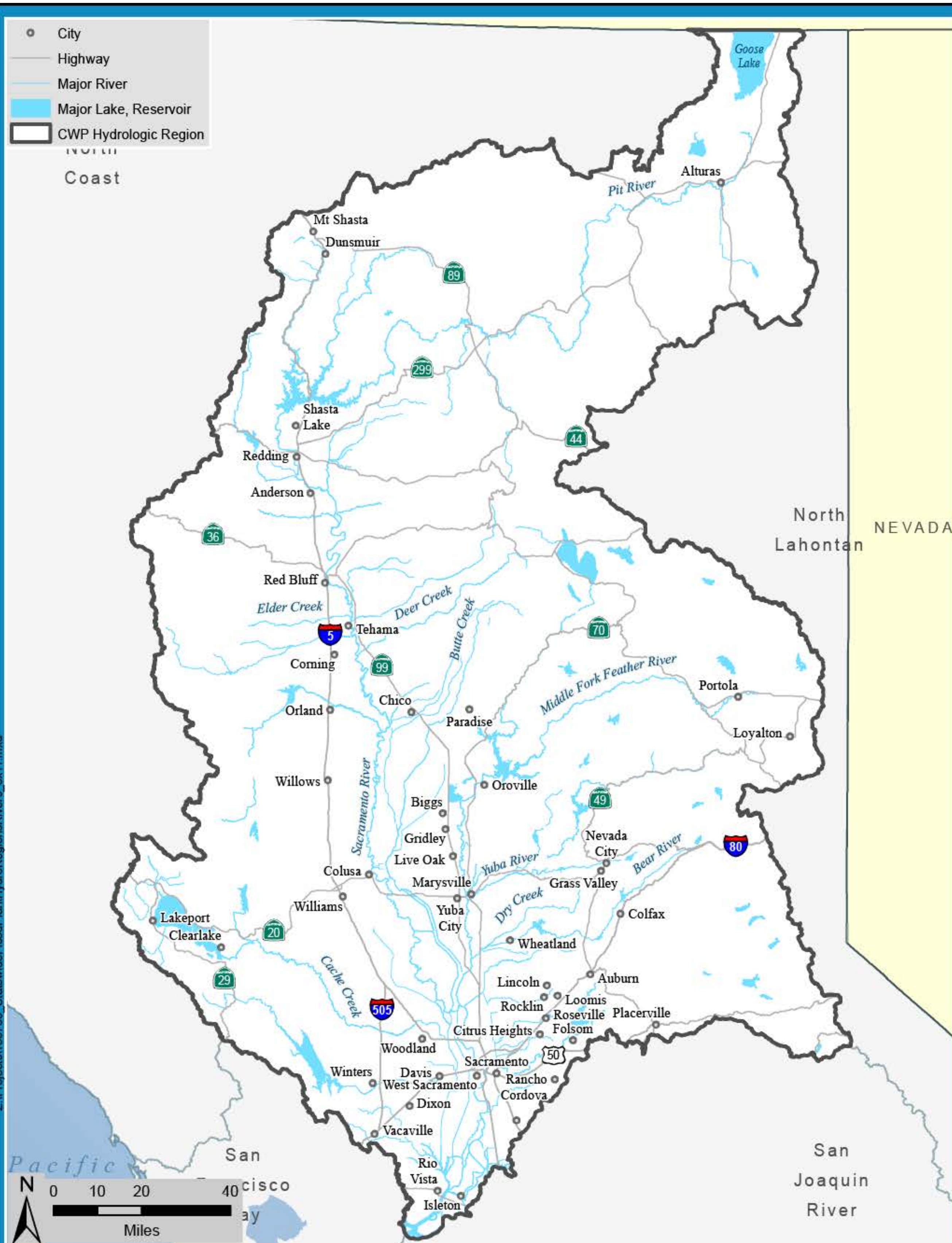
[a]Many Sensitive Species have multiple occurrences throughout the state, and some have very large geographic footprints that may overlap more than one analysis region. As a result, a single Sensitive Species could be counted in more than one analysis region. Because of this, the reported statewide totals will be less than the sum of the individual regions.

The northernmost area of the Sacramento River Hydrologic Region is mainly high desert plateau, characterized by cold, snowy winters with only moderate rainfall, and hot, dry summers. The mountainous parts in the north and east typically have cold, wet winters with large amounts of snow that provide runoff for summer water supplies. The Sacramento Valley floor has mild winters with less precipitation and hot, dry summers. Overall annual precipitation in the region generally increases from south to north and west to east. The snow and rain that fall in this region contribute to the overall water supply for 60 percent of the state. Figure SR-1 illustrates the location of major features in the region, including streams and rivers.

High Water Tower Bridge Sacramento River, March 2011

Stream Descriptions

Table SR-2 provides a detailed description of each watercourse in the Sacramento River Hydrologic Region. In general, streams in the table begin with the Sacramento River and proceed upstream, listing its tributaries and distributaries, with secondary tributaries listed following each primary tributary. Distributaries, shown in italics, (including alternate channels) are most commonly listed at the point of diversion and not listed where they enter another listed stream. The Yolo Bypass and Butte Slough are distributaries with tributary systems of their own, which are described proceeding upstream. Indentations, sub-letters, and numbers indicate tributary status.



Sacramento River Rivers

Figure SR-1 Rivers and Streams of the Sacramento River Hydrologic Region

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

Table SR-2. Stream Descriptions, Sacramento River Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs and Lakes	Mouth Location
SACRAMENTO RIVER STREAM SYSTEM					
1	Sacramento River	E slopes of the Trinity Mountains W of Mount Shasta City	S	Shasta Lake	Suisun Bay
1A	San Joaquin River	Sierra Nevada crest SE of Yosemite National Park	SW, W, NW		Suisun Bay
1A1	Mokelumne River	Near Markleeville	SW, W	Lake Camanche	Near Voorman's Landing
1A2	Old River[a]	W of Lathrop	W, N		San Joaquin River NE of Frank's Tract
1B	Three Mile Slough	N of Decker Island	NE, S		San Joaquin River N of Sherman Island
1C	Georgiana Slough	Walnut Grove	SW		Mokelumne River E of Isleton
1D	Snodgrass Slough	Courtland	S		Walnut Grove
1D1	Morrison Creek	E of Rancho Cordova	SW, S		SW of Lambert
1E	Steamboat Slough	S of Courtland	S, SW		Sacramento River N of Rio Vista
1E1	Cache Slough	SW of Liberty Farms	SE		N of Rio Vista
1E1a	Prospect Slough	SE of Liberty Farms	S		S of Liberty Farms
1E1a1	Shag Slough	NE of Liberty Farms	S		SE of Liberty Farms
1E1b	Lindsey Slough	SW of Liberty Farms	E		S of Liberty Farms
1E1b1	Barker Slough	E of Travis Air Force Base	E		SW of Liberty Farms
1E1c	Haas Slough	E of Fairfield	SE		SW of Liberty Farms
1E1d	Ulatis Creek	Vaca Mountains NW of Vacaville	SE		W of Liberty Farms
1E1e	Sweaney Creek	English Hills N of Vacaville	E, SE		W of Liberty Farms
1E1e1	Alamo Creek	SE slopes of Mt. Vaca	SE, E		E of Vacaville
1F	Sutter Slough	Courtland	S		Steamboat Slough at S tip of Sutter Island
1F1	Miner Slough	SW of Courtland	W, S		Cache Slough at S tip of Prospect Island
1G	Elk Slough	S of Clarksburg	S		Sutter Slough W of Courtland
1H	American River	Sierra Nevada crest from Carson Pass to Donner Summit	SW	Folsom Lake	In Sacramento

Table SR-2. Stream Descriptions, Sacramento River Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs and Lakes	Mouth Location
SACRAMENTO RIVER STREAM SYSTEM					
1I	Natomas East Main Drain	N of Rio Linda	S		N Sacramento
1I1	Arcade Creek	In Orangevale	SW		N Sacramento
1I2	Magpie Creek	Foothill Farms	SW		Del Paso Heights
1I3	Linda Creek (Cirby Creek, Dry Creek)	Beals Point at Folsom Lake	W		S of Rio Linda
1J	Sacramento Bypass	West Sacramento N of Bryte	SW		West Sacramento W of Bryte
1K	Natomas Cross Canal	Pleasant Grove Siding	SW		Verona
1K1	Pleasant Grove Canal	SW of Pleasant Grove	N		Pleasant Grove Siding
1K1a	Pleasant Grove Creek	N of Roseville	W		SW of Pleasant Grove
1K2	East Side Canal	SE of East Nicolaus	S		Pleasant Grove Siding
1K2a	Coon Creek	NW of Auburn	W		SE of East Nicolaus
1L	Feather River	Sierra Nevada and Cascade crest from Sierra Valley to Honey Lake	S, SW, S	Lake Oroville	Verona
1L1	Bear River	NE of Emigrant Gap	SW		S of Marysville
1L1a	Yankee Slough	S of Camp Far West Reservoir	W		Rio Oso
1L1b	Western Pacific Interceptor Canal	Linda	S		S of Olivehurst
1L1c	Dry Creek	SW of Grass Valley	SW		S of Olivehurst
1L2	Yuba River	Sierra Nevada crest from Donner Summit to Sierra Valley	SW		Marysville
1L2a	North Yuba River	W of Sierraville	W	New Bullards Bar Reservoir	E of Dobbins
1L2a1	Downie River	W slopes of Craycroft Ridge	S		Downieville
1L3	Jack Slough	S of Loma Rica	S		At Marysville
1L3a	Simmerly Slough	N of Marysville	S		N of Marysville
1L4	Honcut Creek	S of Lake Oroville	S, W		NE of Live Oak
1L5	North Fork Feather River	Sifford Mountain S of Lassen Volcanic National Park	S		In Lake Oroville
1L6	Middle Fork Feather River	Mountains around S end of Sierra Valley	N, W, SW		In Lake Oroville
1M	Sutter Bypass	W of Meridian	SE		Verona
1M1	Wadsworth Canal	NE of Sutter	SW		SW of Sutter

Table SR-2. Stream Descriptions, Sacramento River Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs and Lakes	Mouth Location
SACRAMENTO RIVER STREAM SYSTEM					
1M1a	East Interceptor	N of Tierra Buena	W		NE of Sutter
1M1b	West Interceptor	NW of Sutter	E		NE of Sutter
1N	Yolo Bypass	SW of Verona	S		N of Rio Vista
1N1	Putah Creek	E slope of Cobb Mountain	SE, E	Berryessa	SE of Davis
1N2	Willow Slough Bypass	S of Woodland	E		NE of Davis
1N3	Cache Creek	Clear Lake	E, SE, E	Clear Lake	E of Woodland
1N3a	North Fork Cache Creek	Little Horse Mountain S of Clear Lake	SE	Indian Valley Reservoir	NE of Clearlake
1N3b	Adobe Creek	NE slopes of Mayacamas Mountains	N	Adobe Reservoir	In Clear Lake
1N3b1	Highland Creek	NE slopes of Mayacamas Mountains	SE, NE	Highland Springs Reservoir	NW of Highland Springs
1N3c	Middle Creek	Elk Mountain N of Clear Lake	S		In Clear Lake
1N3c1	Scotts Creek	NE slopes of Mayacamas Mountains	SE, NW, E		S of Upper Lake
1N3c2	Clover Creek	SW Bartlett Mountain	W		Upper Lake
1N3c2i	Alley Creek	NW Bartlett Mountain	W		N of Upper Lake
1N3c2i1	Page Creek	S Pitney Ridge	SW		N of Upper Lake
1O	Colusa Drain (Colusa Trough, Colusa Basin Drainage Canal)	SW of Ordbend	S, SE		SW of Knights Landing
1O1	Knights Landing Ridge Cut	SW of Knights Landing	SE		Yolo Bypass NE of Woodland
1P	Tisdale Bypass	Tisdale	E		Sutter Bypass E of Tisdale
1Q	Butte Slough	SE of Colusa	SE		Sutter Bypass W of Meridian
1Q1	Butte Creek	Snow Mountain SW of Lake Almanor	S, SW, S		SE of Colusa
1Q1a	Cherokee Canal	N of Shippee	SW		NW of Sutter Buttes
1Q1b	Angel Slough	SW of Chico	S		NW of Sutter Buttes
1Q1b1	Little Chico Creek	W slopes of Doe Mill Ridge	S, SW		SW of Chico
1Q1b1i	Butte Creek Diversion Channel	E of Chico	S		Butte Creek SE of Chico
1R	Colusa Bypass	N of Colusa	E		Butte Creek NE of Colusa

Table SR-2. Stream Descriptions, Sacramento River Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs and Lakes	Mouth Location
SACRAMENTO RIVER STREAM SYSTEM					
1S	Stony Creek	Coast Range crest E of Lake Pillsbury	E, N, E	Black Butte Lake	S of Hamilton City
1T	Big Chico Creek	Colby Mountain SW of Lake Almanor	SW		SW of Chico
1T1	Mud Creek	Cohasset Ridge at Richardson Springs	SW		SW of Chico
1T1a	Sycamore Creek	Musty Buck Ridge NE of Chico	W		N of Chico
1T2	Lindo Channel	Bidwell Park in NE Chico	W		Mud Creek W of Chico
1U	Deer Creek	W of Lake Almanor	SW		Near Vina
1V	Thomes Creek	W of the S Yolla Bolly Mountains	SE, E, NE		S of Los Molinos
1W	Mill Creek	SE of Lassen Volcanic National Park	SW		N of Los Molinos
1X	Elder Creek	E slopes of Valentine Ridge	E		E of Gerber
1Y	Antelope Creek	Turner mountain S of Mineral	SW		N of Dairyville
1Z	Battle Creek	Lassen Peak and vicinity	W		SE of Cottonwood
1AA	Cottonwood Creek	Yolla Bolly to Trinity Mountains	E		E of Cottonwood
1BB	Cow Creek	NE of Redding	SW		E of Anderson
1BB1	Little Cow Creek	Snow Mountain in Lassen National Park	SW		Palo Cedro
1BB2	Oak Run Creek	Cascade Foothills N of Fern	SW		Palo Cedro
1BB2a	Dry Creek[b]	NE of Palo Cedro	SW		E of Palo Cedro
1CC	Clear Creek	Crest of Trinity mountains W of Lamoine	S, E		S of Redding
1CC1	Olney Creek	Mule Mountain W of Redding	SE		SW of Redding
1DD	Churn Creek	S of Shasta Lake	S		S of Enterprise
1EE	McCloud River	Mount Shasta	SW		In Lake Shasta
1EE1	Pit River	S Central Oregon	S, SW		In Lake Shasta[a]
1EE1a	Burney Creek	SW of Burney Mountain	N		In Lake Britton
1EE1b	Hat Creek	W of Chaos Crags	N		In Lake Britton
1EE1c	Ash Creek	Summit Springs W of Madeline	W, NW		W of Adin near Big Swamp
1EE1c1	Dry Creek	SE of Adin	NW		Adin
1EE1d	N Fork Pit River	S of Goose Lake	S, SW		S of Alturas

Table SR-2. Stream Descriptions, Sacramento River Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs and Lakes	Mouth Location
SACRAMENTO RIVER STREAM SYSTEM					
1EE1e	S Fork Pit River	SW slopes of the Warner Mountains	W, N		S of Alturas
1EE2	Squaw Valley Creek	S slope of Mount Shasta	S		S of McCloud
1FF	Castle Creek	NW corner of Shasta County	E		Castella
1GG	Little Castle Creek	N slope of Castle Crags	SE		S of Dunsmuir

Key:

E East, easterly, eastern

N North, northerly, northern

S South, southerly, southern

W West, westerly, western

Notes:

[a]Goose Lake intercepts the flow at the California-Oregon state line. It is a sink, but in a series of extremely wet years, it can overflow into the lower Pit River.

[b]Shasta County

Peak Flows

Table SR-3 provides peak flow information in the Sacramento River Hydrologic Region and shows a correlation between significant flood events and peak flows.

- The highest peak discharges in the Sacramento River region occurred in 1997 on six streams.
- Delta islands are vulnerable to levee failure not only because of subsidence but also because levees are always holding back water.
- Bypass systems usually built to relieve pressure off the regular streams hold more water than the streams themselves.
- Peak discharges of over 100,000 cfs were recorded in five streams in the Sacramento River region.

Table SR-3. Record Flows, Sacramento River Hydrologic Region

Stream	Location	Mean Annual Runoff (taf)	Peak Stage of Record (feet)	Peak Discharge of Record (cfs)	Date of Peak Discharge
OUTSIDE THE SACRAMENTO-SAN JOAQUIN RIVER DELTA					
American River	At Fair Oaks	2,719[b]	28	134,000	2/19/1986
Battle Creek	Below Coleman Fish Hatchery, near Cottonwood	3702	15.8[a,c]	35,000[c]	12/11/1937
Bear River	Near Wheatland	299[b]	24.3[a]	48,000	2/17/1986
Butte Creek	Near Chico	301	17.5[a]	35,600	1/1/1997
Cache Creek	At Yolo	392	86.4[a]	41,400	2/25/1958
Cottonwood Creek	Near Cottonwood	650	21.6	86,000	3/1/1983
Cow Creek	Near Millville	503	26.8[a,c]	48,700	11/16/1981
Deer Creek	Near Vina	235	19.2[a]	24,000	1/1/1997
Feather River	At Oroville	4,491[b]	25.5	161,000	1/2/1997
McCloud River	Above Shasta Lake	567[b]	29	51,300	1/1/1997
Mill Creek	Near Los Molinos	222	23.4	36,400	12/11/1937
Pit River	Near Montgomery Creek	3,552[b]	74.7[a]	73,000	1/24/1970
Sacramento Bypass[f]	Near Sacramento	157[b]	33.0[a]	128,000	2/20/1986
Sacramento River	Above Bend Bridge, near Red Bluff	9,514[b]	36.6[a]	170,000	12/22/1964
Sacramento River	At Verona	14,500[b]	42.1[a]	102,000	1/2/1987
Sacramento River	At Keswick	7,436[b]	32.7[a]	81,400	4/1/1974
Sacramento River	At Colusa	8,518[b]	69.2[a]	51,800	3/4/1983
Yuba River	Near Marysville	1,746[b]	91.6	161,000	1/2/1997

Table SR-3. Record Flows, Sacramento River Hydrologic Region

Stream	Location	Mean Annual Runoff (taf)	Peak Stage of Record (feet)	Peak Discharge of Record (cfs)	Date of Peak Discharge
IN OR IMPORTANT TO THE SACRAMENTO-SAN JOAQUIN RIVER DELTA					
Cosumnes River	At Michigan Bar[d]	362	18.5	93,000	1/2/1997
Mokelumne River	At Woodbridge[d]	403[b]	23.3[a]	5,340	3/8/1986
Putah Creek	Near Winters[d]	349[b]	19.6	18,700	3/2/1983
Sacramento River	At Freeport	17,270[b]	129.6[a,e]	117,000	2/19/1986
San Joaquin River	Near Vernalis	3,308	34.9[a]	79,000	12/9/1950
Yolo Bypass	Near Woodland[d]	2,340[b]	34.9	374,000	2/20/1986

Key:
cfs = cubic feet per second; taf = thousand acre-feet
Notes:
[a]Different date than peak discharge
[b]Most recent but less than period of record
[c]Outside period of record
[d]Located upstream of the legal Delta
[e]Water Years 1946-1977
[f]No flow for all or most of each year

The stations included in this table were selected from all USGS gauging stations in the hydrologic region, according to the criteria:

- The watercourse must be a natural stream with a watershed of at least 100 square miles.
- The station must have a reasonably continuous record of discharge from 1996 to the present.
- The station must be far enough from other stations on the same river to reasonably represent a separate condition.
- Stations in well defined watercourse locations such as deep canyons are omitted, unless particularly important to the overall flood situation.

3.5.2 Historic Floods

Flood damage has been observed in the Sacramento River Hydrologic Region since the early 1800s. Floods can be caused by heavy rainfall; by dams, levees, or other engineered structures failing; or by extreme wet-weather patterns. Historically, flooding occurs in the Sacramento River Hydrologic Region during the winter and spring and is caused by heavy snowpack that is melted by severe rainfall events. This flooding rises slowly in the region and can have lengthy runoff periods. Flooding in the Sacramento River Hydrologic Region is predominantly slow rise; however, flash floods and stormwater flooding occur frequently in the region. Other flooding types include debris flows floods, which occur rarely, as well as alluvial fan flooding and tsunamis, which are even rarer.

***The Climate of California on a Rampage*, woodcut**

Hydraulic mining in upstream reaches of the region (during the late 1800s) exacerbated downstream flooding by depositing millions of tons of sediment in the riverbeds (limiting flows). For this reason, flooding is common in the Sacramento River Hydrologic Region, and many miles of levees have been constructed. These levees include older ones that were mostly constructed without benefit of modern engineering and are particularly vulnerable resulting in a high incidence of floods caused by structural failure. This is particularly true of the levees in the Delta.

Coastal flooding, in the sense of inundation due to a rise in water level, occurs in the Delta and at Clear Lake. Some of the most at-risk levees are in the Delta, where lands that have subsided are subject to continuous waterside inundation. Other types of flooding occur only occasionally. Since the era of building levees began, floods have become less frequent but more damaging. Table SR-4 is an abridged synopsis of major floods in the region. For a more comprehensive list of flood events in the region, see Appendix B. Selected significant floods are briefly described below.

1861-62: The "Great Flood." This flood in the winter of 1861-62 was remarkable for the exceptionally high stages reached on most streams, repeated large floods, and prolonged and widespread inundation in the Sacramento River basin. Lower elevations experienced heavy rain, and upper elevations saw continuous snowfall. The regional event was only part of a deluge that encompassed all of California, much of Oregon, and parts of Utah and Nevada (Utah Territory), Arizona (New Mexico Territory), and Idaho (Washington Territory). Sacramento was a focus of the damage, as early-day levees failed.

Yuba City Flooding, 1955

November 1950-January 1951. The American River inundated extensive areas on the north bank in the city of Sacramento. Yuba River flooded the communities of Linda and Olivehurst in 1950. Heavy November rains caused extensive flooding in the Sacramento Basin. Floodwaters from the Yuba River inundated large areas thought to be adequately protected from flood flows by the downstream project reaches. The communities of Hammonton, Linda, Olivehurst, Arboga, and over 40,000 acres of agricultural land, including Reclamation District 784, were swamped by the overflow.

Yuba River Flooding, 1955

December 1955. The "Christmas Day Flood" from the west side levee breach on the Feather River killed 40 people, caused the mandatory evacuation of over 30,000, and devastated the region's economy. This was an all-time record flow, the worst flood in northern California. The December 1955 flood brought large flows to many locations in the Sacramento River Basin. A levee break on the Feather River caused severe flooding in the Yuba City area.

February-April 1958. Flood damage resulting from two storm periods occurred in February in the North Coastal area, in the northern Sacramento Valley, near Clear

Lake, and throughout most of Northern California in April. The later floods inundated areas in or near Hamilton City, Stockton, Walnut Creek, Brentwood, Mendota, Patterson, Mill Valley, Napa, and the Sacramento-San Joaquin Delta. Several locally owned levees failed or were overtopped in the Central Valley and in scattered coastal areas.

December 1962-February 1963. Numerous communities were flooded and damaged in the American and Yuba River basins. In the Delta, Prospect Island, Liberty Island, and Little Holland Tract flooded.

December 1964-January 1965. Abnormally heavy and continuous rainfall and windstorm occurred throughout counties of Shasta, Colusa, Glenn, Lassen, Plumas, Sierra, Siskiyou, Sutter, Tehama, Butte, El Dorado, Modoc, Nevada, Placer, and Yuba. The main center of precipitation was in the basins of the Feather, Yuba, and American rivers.

December 1969-January 1970. Heavy winds, storms, and flooding were prevalent throughout the counties of Butte, Colusa, Glenn, Lake, Lassen, Modoc, Plumas, Shasta, Siskiyou, Tehama, Sutter, Yuba, and El Dorado. Statewide damage amounted to $27,657,478. In the Sacramento Valley, floodwaters produced by the January 1969 storms were largely controlled by major reservoirs, flood channels, and the bypass system.

January-April 1974. Two major floods occurred in the Sacramento Valley. The first occurred from January 11 through 19, 1974, and the second from March 28 through April 1, 1974. Reported economic losses in Shasta County amounted to $10,650,000. Damage from the 1974 flood in Dunsmuir was estimated to be $4.2 million, with 25 homes destroyed.

December 1982-March 1983. Heavy rains, high winds, flooding, and levee breaks produced regionwide damages of $523,617,032. Brought on by El Niño weather conditions, extremely wet conditions coupled with voluminous Sierra runoff led to very high river stages throughout the system and caused extensive damage to the flood management system of the Sacramento Valley.

Linda Levee Break on the South Fork Yuba River, 1986

February 1986: St. Valentine's Day Storm. Rains, winds, flooding and mudslides occurred. The floods of 1986 caused extensive damage to the flood management system of the Sacramento Valley. The storms caused nearly $50 million in public and private property damage, excluding damage to roads and other infrastructure. In the northern Delta, 1,600 people were evacuated, and $20 million in property damage occurred.

December 1996-January 1997. The fifth record flood in 46 years occurred over the New Year holiday. Storms caused one of the worst floods of the century. McCormack-Williamson Tract and Dead Horse Island levees failed. High flows in the San Joaquin River led to failure of a levee at Mossdale, flooding that area and Stewart Tract, and the nearby Paradise Cut levee breach flooded the Pescadero District.

Table SR-4. Selected Flood Events, Sacramento River Hydrologic Region

Date	Location	Flood Type	Description	County
1805	Central Valley	Slow Rise	Flood reportedly inundated “the entire valley floor The flood caused much loss of life and destruction in Indian villages.	Butte, Colusa, El Dorado, Glenn, Placer, Sacramento, Shasta, Sutter, Tehama, Yuba, Yolo
1846	Sacramento	Slow Rise	A New York Times article in 1862 noted that in Sacramento in 1846, the water was 7 feet deep for 60 days.	Sacramento
1849-1850	Shasta	Slow Rise	There was extensive flooding in northern California. Flooding occurred on the Sacramento and American rivers, washing out bridges and flooding the city of Sacramento, resulting in much damage to homes and lost lives. The city was navigated in whale ships. Significant areas of the valley were inundated, with the river being several miles wide for more than 100 miles downstream—"an unbroken sea of waters." Major floods were recorded during this time	Shasta
December 1861-January 1862 “The Great Flood”	American Rivers Cottonwood Creek, Feather, Bear, Sacramento River, Yuba	Slow Rise	This flood in the winter of 1861-62 was remarkable for the exceptionally high stages reached on most streams, repeated large floods, and prolonged and widespread inundation in the Sacramento River basin. Lower elevations experienced heavy rain, and upper elevations saw continuous snowfall. The regional event was only part of a deluge that encompassed all of California, much of Oregon, and parts of Utah and Nevada (Utah Territory), Arizona (New Mexico Territory), and Idaho (Washington Territory). Sacramento was a focus of the damage, as early-day levees failed.	Butte, Colusa, El Dorado, Glenn, Lake, Lassen, Modoc, Napa, Nevada, Placer, Plumas, Sacramento, Shasta, Siskiyou, Solano, Sonoma, Sutter, Tehama, Yolo, Yuba
December 1937-March 1938	Regionwide	Slow Rise	Reliable evidence indicates that the highest river stages ever noted were reached in December 1937 at certain points on the Sacramento River and tributaries in the general vicinity of Red Bluff. Many places in the region suffered damage, including Chester, Downieville, Gerber, Tehama, and agricultural areas in Tehama, Glenn, and Colusa counties.	Alpine, Butte, Colusa, El Dorado, Glenn, Lake, Lassen, Modoc, Napa, Nevada, Placer, Plumas, Sacramento, Shasta, Sierra, Siskiyou, Solano, Sutter, Tehama, Yolo, Yuba

Table SR-4. Selected Flood Events, Sacramento River Hydrologic Region

Date	Location	Flood Type	Description	County
January-February 1942	Regionwide	Slow Rise, Structure Failure	The Sacramento River flooded farmland near Tehama and Vina, and the Feather River flooded lands between Oroville and Marysville.	Alpine, Butte, Colusa, El Dorado, Glenn, Lake, Lassen, Modoc, Napa, Nevada, Placer, Plumas, Sacramento, Shasta, Sierra, Siskiyou, Solano, Sutter, Tehama, Yolo, Yuba
November 1950- January 1951	American River, City of Sacramento, Del Paso Heights, Lowlands south of the Yuba River, Olivehurst, suburban Sacramento, Yankee Slough, Yuba River	Slow Rise, Structure Failure	Newspaper accounts of rainfall and stream gauge records indicated that Sacramento County experienced significant flooding. In the city of Sacramento, the American River inundated extensive areas on the north bank, including the area in the vicinity of Fulton Avenue and Fair Oaks Boulevard. Yuba River flooded the communities of Linda and Olivehurst in 1950. Heavy November rains caused extensive flooding in the Sacramento Basin.	Nevada, Sacramento, Solano, Sutter, Yuba
December 1955 "1955 Christmas Flood"	Butte Creek, Yuba City and Nicolaus (Sutter)	Flash, Engineered Structure Failure	The "Christmas Day Flood" from the west-side levee breach on the Feather River killed 40 people, caused the mandatory evacuation of over 30,000, and devastated the region's economy. This was an all-time record flow, the worst flood in northern California. The December 1955 flood brought large flows to many locations in the Sacramento River Basin. A levee break on the Feather River caused severe flooding in the Yuba City area.	Butte, Colusa, El Dorado, Glenn, Lake, Lassen, Modoc, Napa, Nevada, Placer, Plumas, Sacramento, Shasta, Sierra, Siskiyou, Solano, Sutter, Tehama, Yolo, Yuba
February 1958	Cache Creek, Clear Lake, Colusa Basin Drain, Delta: area west of Galt, McCormack-Williamson Tract, Dead Horse Island, Prospect Island, Liberty Island, Little Holland Tract, Hamilton City; Northern Sacramento Valley, Stony Creek	Slow Rise, Structure Failure	Flood damage resulting from two storm periods occurred in February in the North Coastal area, in the northern Sacramento Valley, near Clear Lake, and throughout most of Northern California in April. The later floods inundated areas in or near Hamilton City, Stockton, Walnut Creek, Brentwood, Mendota, Patterson, Mill Valley, Napa, and the Sacramento-San Joaquin Delta. Several locally owned levees failed or were overtopped in the Central Valley and in scattered coastal areas	Colusa, Glenn, Lake, Lassen, Modoc, Sacramento, Solano, Sonoma, Sutter, Yolo

Table SR-4. Selected Flood Events, Sacramento River Hydrologic Region

Date	Location	Flood Type	Description	County
October 1962	Adin, Alturas, Chico, Delta: Liberty Island, Little Holland Tract, Prospect Island; Dry Creek, Oroville, Redding, Roseville, Sacramento, Sacramento Valley, Tobin, Wheatland	Slow Rise, Engineered Structure Failure, Debris flow	The Sacramento River Flood Control Project, an extensive system of dams, levees, and floodways, functioned very efficiently. Shasta Lake controlled the flow in the reach of the Sacramento River immediately below the lake, and Folsom Lake controlled the flow in the American River. Potential floodwaters that were retained in each of these reservoirs amounted to more than 200,000 acre-feet. In the lower reaches of the Sacramento Valley, Sutter and Yolo bypasses were utilized as the Sacramento River spilled over the Colusa, Tisdale, and Fremont relief weirs. The principal area of flood damage was along the Feather River near Oroville, where the river reached its highest October stage of record and swept away a cofferdam and part of a fish hatchery that was under construction. Urban areas, including the city of Sacramento, were damaged by local runoff, and agricultural and highway damages were appreciable. There was also minor damage in secondary channels in the Sacramento Valley, caused primarily by accumulated drift on bridges.	Butte, Lassen, Placer, Plumas, Modoc, Sacramento, Shasta, Sierra, Solano, Sutter, Yolo, Yuba
December 1962-February 1963	Statewide, American River, Chester, Delta: Liberty Island, Little Holland Tract; Portola, Quincy, Sacramento Valley, Yuba River Basins,	Slow Rise, Engineered Structure Failure	Numerous communities were flooded and damaged in the American and Yuba river basins. In the Delta, Prospect Island, Liberty Island, and Little Holland Tract flooded.	Colusa, El Dorado, Glenn, Lake, Lassen, Napa, Nevada, Placer, Plumas, Sacramento, Sierra, Siskiyou, Solano, Sutter, Tehama, Yolo, Yuba
December 1964-January 1965	Butte Creek, Dry Creek, Laguna Creek, Lower Hell Hole Dam, Morrison Creek, Sacramento River - City of Dunsmuir	Slow Rise, Coastal, Structure Failure	Abnormally heavy and continuous rainfall and windstorm occurred throughout counties of Shasta, Colusa, Glenn, Lassen, Plumas, Sierra, Siskiyou, Sutter, Tehama, Butte, El Dorado, Modoc, Nevada, Placer, and Yuba. This was the first large flood after the devastating 1955 flood. The main center of precipitation was in the basins of the Feather, Yuba, and American rivers. Rainfall was heaviest December 22 and 23, 1964. Runoff from streams of the Coast Ranges, almost without exception, produced peak stages and peak flows that exceeded previous records. Runoff from the Sierra into the Feather, Yuba, and American rivers surpassed all previous records.	Butte, Colusa, El Dorado, Glenn, Lake, Lassen, Modoc, Nevada, Placer, Plumas, Sacramento, Shasta, Sierra, Siskiyou, Solano, Sutter, Tehama, Yolo, Yuba

Table SR-4. Selected Flood Events, Sacramento River Hydrologic Region

Date	Location	Flood Type	Description	County
December 1966-March 1967	Arcade Creek, Colusa Basin, Fairfield, Feather River, Sacramento River Basins,	Slow Rise	Three major storm periods between December 1966 and March 1967 deposited above-normal precipitation in the Sacramento River Basin, flooding 219,000 acres. Virtually all of the flooded area was cropland, orchards, pasture or grazing land within the confines of flood channels and overflow basins. A large area flooded was the Colusa Basin, a natural overflow trough of the Sacramento River. Rainfall and stream gauge records indicated that Sacramento experienced significant flooding during January 1967. Arcade Creek overflowed its banks upstream of the Sacramento corporate limits, and flooding in the city was restricted to minor inundation in Del Paso Park. Moderate agricultural damages estimated were estimated at $104,000; an estimated 8,070 acres were flooded. Significant flooding occurred on Laguna Creek, which overflowed into its floodplain. Dry Creek and Robla Creek, however, overflowed inside the city.	Butte, Colusa, El Dorado, Glenn, Lake, Lassen, Modoc, Nevada, Placer, Plumas, Sacramento, Sutter, Solano, Shasta, Tehama, Yolo, Yuba
December 1969-March 1970	American River, Sacramento River,	Slow Rise, Flash	Heavy winds, storms, and flooding were prevalent throughout the counties of Butte, Colusa, Glenn, Lake, Lassen, Modoc, Plumas, Shasta, Siskiyou, Tehama, Sutter, Yuba, and El Dorado. Statewide damage amounted to $27,657,478. In the Sacramento Valley, floodwaters produced by the January 1969 storms were largely controlled by major reservoirs, flood channels, and the bypass system. As a result, flows in the mainstem of the Sacramento River and its major tributaries remained well below project design lows. However, several unimproved valley and foothill streams overflowed their banks and caused local flooding.	Butte, Colusa, El Dorado, Glenn, Lake, Modoc, Nevada, Placer, Plumas, Shasta, Siskiyou, Sonoma, Yolo, Yuba
January 1974	Regionwide	Slow Rise, Debris Flow, Engineered Structure Failure	Residences were inundated due to failed levees, many roads were washed out by high flows, and large sediment loads were deposited on agricultural lands. Flooding was characterized by extremely large flows, including record flows at some locations. The Sacramento River Flood Control Project and other flood management programs had been implemented. Project levees, dams, reservoirs, and waterways were employed to control much of the flood flows through the Sacramento system; however, local flooding, mostly on agricultural lands, still occurred.	El Dorado, Lassen, Modoc, Nevada, Placer
October-December 1981	Delta: Prospect Island	Slow Rise, Engineered Structure Failure	Heavy storms raised river levels, leading to another failure of the Prospect Island levee and failure of Little Franks Tract, 200 acres, in December.	Solano

Table SR-4. Selected Flood Events, Sacramento River Hydrologic Region

Date	Location	Flood Type	Description	County
December 1982-March 1983	Regionwide. Sacramento-San Joaquin Delta: Central Valley	Slow Rise	Heavy rains, high winds, flooding, and levee breaks caused regionwide damages of $523,617,032. Brought on by El Niño weather conditions, extremely wet conditions coupled with voluminous Sierra runoff led to very high river stages throughout the system and caused extensive damage to the flood management system of the Sacramento Valley.	Butte, Colusa, El Dorado, Glenn, Lake, Lassen, Modoc, Nevada, Placer, Shasta, Solano, Sonoma, Sutter, Tehama, Yolo, Yuba
February 1986 "St. Valentine's Day	Regionwide, Delta: Dead Horse, Tyler Islands, McCormack-Williamson Tract	Slow Rise, Stormwater	Rains, winds, flooding and mudslides occurred. The floods of 1986 caused extensive damage to the flood management system of the Sacramento Valley.	Alpine, Butte, Colusa, El Dorado, Glenn, Lake, Lassen, Modoc, Napa Nevada, Plumas, Shasta, Sierra, Siskiyou, Solano, Sonoma, Sutter, Tehama, Yolo, Yuba
February-March 1995	Regionwide	Flash, Debris Flow	Severe winter storms, flooding, landslides, and mud flows caused 17 statewide deaths. Statewide damage was approximately $1,100,000,000	Butte, Colusa, El Dorado, Glenn, Lake, Lassen, Modoc, Napa, Nevada, Placer, Plumas, Sacramento, Shasta, Sierra, Siskiyou, Solano, Sutter, Tehama, Yolo, Yuba
December 1996-January 1997	Regionwide—Delta: Dead Horse Island, McCormack-Williamson Tract, Unincorporated areas of McCloud; Carson Pass, Squaw and Panther Creeks	Slow Rise, Structure Failure	Storms caused one of the worst floods of the century. There was widespread flooding and flood damage across the region from the major rivers and creeks in the Sierra Nevada.	Alpine, Butte, Colusa, El Dorado, Glenn, Lake, Modoc, Napa, Nevada, Placer, Plumas, Sacramento, Shasta, Sierra, Siskiyou, Tehama, Yolo, Sutter, Yuba
December 2005– January 2006	South Lake Tahoe, Trout Creek, Feather River, Sacramento River	Flash, Slow Rise	Severe storms, flooding, mudslides, and landslides. Damages $128,964,501.	Butte, Contra Costa, El Dorado, Lake, Modoc, Napa, Nevada, Plumas, Sacramento, Shasta, Siskiyou, Solano, Yuba

3.5.3 History of Flood Response

In the Sacramento River Hydrologic Region, the major types of flooding include slow rise, flash, and stormwater flooding. As a result of and in response to the regionally specific flood risks, a number of traditional flood management projects have been developed. These include construction of a network of lakes and reservoirs for flood control, levees, pumping plants, channel improvements, settling basins, and floodplain zoning ordinances.

Flood Management Infrastructure

The Sacramento River Hydrologic Region contains floodwater storage facilities and channel improvements partially funded or co-sponsored by local, State, and Federal agencies. Flood management agencies are responsible for operating and maintaining more than 3,650 miles of levees, more than 400 dams, 28 debris basins, and other facilities within the Sacramento River Hydrologic Region, not all of which are dedicated for flood management or have flood storage. Facilities in the region include seven reservoirs with flood management reservations, a natural lake that moderates flood peaks, a reservoir with flood management responsibilities (no space reservation), levees, bypasses, pumping plants, weirs, a debris basin, channels, and bank protection.

Consumnes River Levee Break, 1997

The Sacramento River Flood Protection (SRFP) system operates in concert with the listed reservoirs and lakes, although none of them is part of the system. The system features two debris basins, two major bypasses for the main river, three other bypasses that act as exit channels for weirs, six weirs, about 1,000 miles of levees on the Sacramento River and 58 of its tributaries, distributaries, diversions, bank protection, and interior drainage facilities that include levees, channels, and pumping plants. Four of the constituent projects are at remote locations tributary to the river.

Other regional flood management facilities include channel improvements on Ulatis Creek, a realignment of Alamo Creek near Vacaville, and levees constructed and maintained by local government or individuals (such as the levees around Delta islands and along Deer Creek near Sloughhouse).

For a comprehensive list of major infrastructure, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*. Also, flood infrastructure maps for each county are provided in *Attachment D: Summary of Exposure and Infrastructure by County (Mapbook)*.

Flood Management Governance

Although primary responsibility for flood management might be assigned to a specific local entity in the Sacramento River Hydrologic Region, aggregate responsibilities are spread among more than 320 agencies with many different governance structures. Some of the larger agencies in the Sacramento River Hydrologic Region include the following:

- Butte County Public Works
- Colusa Basin Drainage District
- Colusa County Public Works
- El Dorado County Glenn Colusa Irrigation District
- Lake County Watershed Protection District
- Napa County Flood Control and Water Conservation District
- Nevada County
- Placer County Flood Control and Water Conservation District
- Plumas County Flood Control and Water Conservation District
- American River Flood Control District
- City of Sacramento
- Sacramento County Department of Water Resources
- Shasta County Water Agency
- Solano County Sutter Butte Flood Control Agency
- West Sacramento Flood Control Agency
- Sacramento Area Flood Control Agency
- Yolo County

Construction within the Floodplain (survey pole denotes elevation of 100-year flood event)

Agency roles and responsibilities can be limited by how the agency was formed, which might include enabling legislation, a charter, a memorandum of understanding with other agencies, or ownership. In this region, a number of irrigation and reclamation districts are responsible for flood projects. These agencies were typically developed to address irrigation and flood management. A comprehensive list of agencies with flood management responsibilities can be found in *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

Flood-Related Regulations

Several agencies in the region have implemented regulations that directly impact flood management and land use within floodplains. For example, the CVFPB has designated reaches of the Sacramento, Yuba, Feather, and American rivers and Stony, Clear, Cow, Cottonwood, Willow, and Dry creeks as regulated floodways. This limits what can be constructed with the floodways for specific design storm events (e.g., 100-year event). Cities troubled by localized flooding have also adopted streams as designated floodways.

Zoning ordinances regulating development in floodplains have been adopted by all counties within the last 30 years. Additionally, numerous cities—such as Sacramento, Auburn, Marysville, and Winters— restrict construction within floodplains via building codes. Local land use jurisdictions have adopted floodplain management ordinances, identifying 100-year event floodplains and floodways to qualify for participation in FEMA's NFIP.

Flood Emergency Planning Efforts

Emergency management is important because these programs can be used to inform the public, policymakers, and local agencies how to respond to a flood event, which can help save lives when a flood event occurs. This is a significant issue in the Sacramento River region due to the danger of slow rise, flash, and engineered structure failure flooding.

Forecast-Coordinated Operations. In 2005, Yuba County Water Agency, USACE, the National Weather Service, and DWR initiated a two-phase development program for forecast-coordinated operations of New Bullards Bar Reservoir on the North Yuba River and Lake Oroville on the Feather River. The first phase (Design) was completed, and the agencies have signed a contract for implementation. The system includes improved flood forecasting tools, additional gauging stations, improved weather and runoff forecasting models, annual exercises, and improved data exchange among the four agencies, as well as with downstream levee operators and emergency operations staffs.

Multi-Hazard Mitigation Plans. There are at least 19 completed MHMPs for the region. For a comprehensive list of FEMA-approved MHMPs in the Sacramento River Hydrologic Region with corresponding dates of approval, refer to Appendix D.

Flood Insurance. FEMA has provided FIRMs for most areas within the region. FIRMs in 4 of the region's 22 counties are new since 2005, and 12 more were scheduled to be updated by 2010. Two counties had a partial update in 2008, and 4 have not scheduled an update. In the Sacramento River Hydrologic Region, eight counties and seven cities participate in the CRS program; for a list of participating agencies, see Table C-4, California Communities CRS Participation and Savings.

3.5.4 Current Flood Management

The Sacramento River Hydrologic Region has 163 local and USACE flood management projects or planned improvements, as identified by the Flood Future Report information gathering effort. Of these 163 projects, 83 projects have estimated costs totaling approximately $2.54 billion (not including CVFPP-proposed projects). Sixty-nine of the local planned projects involve multiple benefits beyond the flood component and, therefore, qualify as IWM projects, with costs totaling approximately $280 million. An example of an IWM project with components for flood management and water supply in the Sacramento River Hydrologic River Region is the Butte Creek Meadow Restoration Project in Lassen County. The project will restore approximately 150 acres of meadows to provide flood attenuation and shallow groundwater recharge.

These projects and improvements are summarized in *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

In addition, DWR administers the IRWM Grant Program. Seven of the 10 IRWM plans that are within jurisdiction of the Sacramento River Hydrologic Region address flood management issues. These plans include the following:

- American River Basin IRWM Plan, adopted in 2006, identifies 17 flood or stormwater management projects and highlights 5 of them as flood control projects of the Sacramento Area Flood Control Agency (RWA, 2006).
- Cosumnes, American, Bear, Yuba Region IRWM Plan, 2013, recommends projects that reduce flood damages to existing water resource infrastructure and notes the connection between flood control and ecosystem benefits (CABY, 2013).
- Solano Agencies IRWM Plan, adopted in 2005, lists no flood control infrastructures to be constructed in the near term; however, it does discuss updating its flood control plan and flood hazard maps, establishing more clearly its flood control duties with other agencies and evaluating the safety of its major structures such as Monticello Dam, which impounds Lake Berryessa (Solano Agencies, 2005).
- Upper Feather River IRWM Plan, established in 2005, seeks to minimize flood damages by promoting projects that increase floodwater retention via higher interception and infiltration rates, along with projects that maintain/restore channel capacities by retarding high sediment yields (County of Plumas et al., 2005).
- The Sacramento Valley IRWM Plan (Northern California Water Association, 2006), Yolo County IRWM Plan (WRA, 2005), and Yuba County IRWM Plan (2008) also address flood control issues.
- The Upper Pit River Watershed IRWM Plan has been completed (PRWA, 2013).

Flooding along American River, 1997

3.6 San Francisco Bay Hydrologic Region

3.6.1 Regional Setting

The San Francisco Bay Hydrologic Region extends along the Pacific Coast from Tomales Bay to southern Santa Clara County and inland to the confluence of the Sacramento and San Joaquin rivers near Collinsville. The eastern boundary generally follows the crest of the Coast Range. The dominant topographic features are San Francisco Bay, Tomales Bay, Suisun Bay and Suisun Marsh, the Coast Ranges, and Napa Valley. The region is highly urbanized in places. Streams in the region flow into the bay estuary or the Pacific Ocean.

In the San Francisco Bay Hydrologic Region, approximately 1 million people and 44,000 acres of agricultural crops are exposed in the 500-year floodplain. More than 270 plant and animal species that are State or Federally listed as threatened, endangered, or rare are exposed to flood hazards in the region. Table SF-1 provides a snapshot of people, structures, crops, infrastructure, and sensitive species that are exposed to flood hazards in 100-year and 500-year flood events.

Table SF-1. San Francisco Hydrologic Region Exposures within the 100-Year and 500-Year Floodplains

Segment Exposed	100-year (1%) Floodplain	500-year (0.2%) Floodplain
Population(% total exposed)	355,000 (6%)	1,041,400 (17%)
Total Depreciated Replacement Value of Exposed Structures and Contents	$46.2 billion	$133.8 billion
Exposed Crop Value	$17.3 million	$23.9 million
Exposed Crops (acres)	33,300	44,000
Tribal Lands (acres)	0	0
Essential Facilities (count)	140	466
High Potential-Loss Facilities (count)	168	303
Lifeline Utilities (count)	47	58
Transportation Facilities (count)	560	1,022
Department of Defense Facilities (count)	8	8
Plant species State- or Federally listed as Threatened, Endangered, or Rare[a]	167	169
Animal species State- or Federally listed as Threatened, Endangered, or Rare[a]	106	110

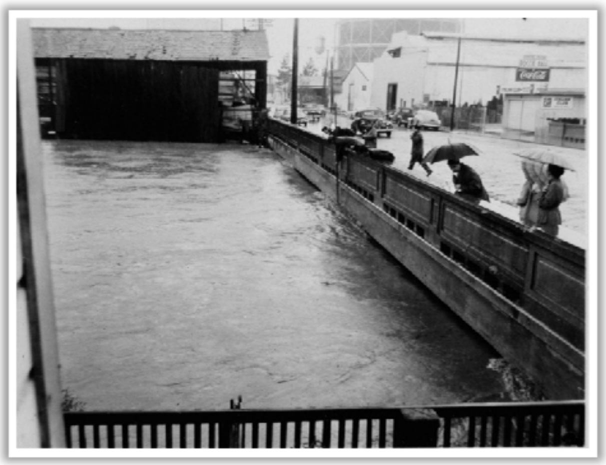
Note:

[a]Many Sensitive Species have multiple occurrences throughout the state, and some have very large geographic footprints that may overlap more than one analysis region. As a result, a single Sensitive Species could be counted in more than one analysis region. Because of this, the reported statewide totals will be less than the sum of the individual region reports.

Stream Descriptions

Figure SF-1 illustrates the location of major features in the region, including streams and rivers. Table SF-2 includes a description of each watercourse mentioned in connection with the San Francisco Bay Hydrologic Region. Indentations, sub-letters, and numbers indicate tributary status. The descriptions begin in San Francisco Bay north of the Golden Gate Bridge and proceed clockwise around the bay and then southward down the coast, with tributaries listed in upstream order. Indentation indicates tributary status.

Like most of northern California, the climate in the San Francisco Bay Hydrologic Region is largely governed by weather patterns originating in the Pacific Ocean, primarily by the southern descent of the polar jet stream, bringing with it mid-latitude cyclonic storms in winter. About 90 percent of the precipitation in the region falls between November and April. The north bay area receives about 20 to 25 inches of rain. In the south bay area, east of the Santa Cruz Mountains, annual precipitation is about 15 to 20 inches because of the rain-shadow effect. Some higher elevations in the region, particularly along the west-facing slopes, average more than 40 inches of rain per year. Historical variation since 1914 for the San Francisco Bay Hydrologic Region ranges from 9 to 44 inches per year with an average of 21 inches per year.



Flooding Guadalupe River

San Francisco Bay Rivers

Figure SF-1 Rivers and Streams of the San Francisco Bay Hydrologic Region

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

Table SF-2. Stream Descriptions, San Francisco Bay Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM SYSTEMS ENTERING SAN FRANCISCO BAY OR A CONNECTED BAY, MARSH, OR STRAIT					
1	Coyote Creek[a]	W of Tamalpais Valley	E		Richardson Bay
2	Corte Madera Creek	N of Mt. Tamalpais	SE		Corte Madera
3	Novato Creek	Stafford Lake N of Novato	E		San Pablo Bay near Black Point
3A	Arroyo Avichi	W of Novato	E		Novato
3B	Warner Creek	SW of Novato	NE		Novato near Highway 101
4	Petaluma River	NW of Petaluma	SE		San Pablo Bay near Black Point
4A	San Antonio Creek	W of Petaluma	E		4 mi upstream of San Pablo Bay
4B	Washington Creek	NE of Petaluma	SW		Petaluma
4C	Lynch Creek	Sonoma Mountain	SW		Petaluma
4D	Willow Brook	Stony Butte	SW		NW of Petaluma
5	Sonoma Creek	Bald Mountain NW of Kenwood	SW, SE		N end of San Pablo Bay
5A	Nathanson Creek	Hogback Mountain	S		Near Wingo
6	Napa River	Mayacamas Mountains NW of Calistoga	SE		San Pablo Bay at Vallejo
6A	White Slough	Vallejo SW of Lake Chabot	NW		Vallejo N of Mare Island Strait
6B	Tulucay Creek	E of Napa	W		Napa S of Highway 121
6C	Napa Creek	W part of Napa	E		Napa near Second Street
6D	Conn Creek	Howell Mountain near Angwin	SE, NW		Near Yountville
7	Green Valley Creek	NE of Napa	S		Suisun Marsh near Cordelia
7A	Dan Wilson Creek	W of Fairfield	S		S of Cordelia
8	Ledgewood Creek	Blue Ridge[c]	SE		Suisun Marsh near Suisun City
9	Pennsylvania Avenue Creek	W part of Fairfield	S		Suisun Marsh S of Fairfield
10	Laurel Creek	Vaca Mountains SW of Vacaville	S		Suisun Marsh at Suisun City
10A	Union Avenue Creek	Fairfield	S		Fairfield

Table SF-2. Stream Descriptions, San Francisco Bay Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM SYSTEMS ENTERING SAN FRANCISCO BAY OR A CONNECTED BAY, MARSH, OR STRAIT					
11	McCoy Creek	NE of Fairfield	S		Suisun Marsh
12	Sacramento River	Mt. Shasta City	S		Suisun Bay near Chipps Island
12A	San Joaquin River	Sierra Nevada NE of Madera	SW, NW		W of Sherman Island
13	Pacheco Creek	Pacheco	N		Suisun Bay E of Martinez
13A	Walnut Creek	City of Walnut Creek	N		N part of Concord
13A1	Galindo Creek	Mount Zion	W		Concord
13A1a	Pine Creek	NE of City of Walnut Creek	NW		Concord
13B1	Grayson Creek	In and SE of Briones Hills	NE		N of Concord
13B2	San Ramon Creek	W of San Ramon	E, NW		City of Walnut Creek
13B3	Las Trampas Creek	N end of Rocky Ridge near Moraga	N, E		City of Walnut Creek
14	Alhambra Creek	Briones Hills	N		Carquinez Strait
15	Rodeo Creek	Briones Hills	NW		San Pablo Bay at Rodeo
16	Pinole Creek	Briones Hills	W		San Pablo Bay at Pinole
17	Rheem Creek	E part of San Pablo	W		San Pablo Bay S of Pinole Point
18	San Pablo Creek	W of Orinda	W, NW		San Pablo Bay W of San Pablo
19	Wildcat Creek	Tilden Regional Park	NW		San Pablo Bay W of North Richmond
20	San Leandro Creek (two branches)	SW of Round Top near Orinda; Ramage Peak	SE, SW; S, SW		San Leandro Bay in Oakland
21	San Lorenzo Creek	Wiedemann Hill W of Castro Valley	SW		San Francisco Bay at San Lorenzo
21A	Crow Creek	Rocky Ridge W of San Ramon	S		Just below Don Castro Reservoir
21A1	Cull Creek	Ramage Peak	S	Cull Creek Reservoir	E part of Castro Valley
22	Alameda Creek	Packard Ridge N of Mount Hamilton	NW, W		San Francisco Bay W of Fremont

Table SF-2. Stream Descriptions, San Francisco Bay Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM SYSTEMS ENTERING SAN FRANCISCO BAY OR A CONNECTED BAY, MARSH, OR STRAIT					
22A	Line A Channel	Union City	NW		Fremont
22B	Arroyo de la Laguna	Dublin	S		Near Sunol
22B1	Arroyo Valle	Mount Hamilton	N, W	Lake Del Valle	W part of Pleasanton
23	Coyote Creek[b]	Blue Ridge[b]	SE, NW, W		San Francisco Bay N of Sunnyvale
23A	Guadalupe River (Alviso Slough)	Santa Teresa Hills	NW		Near San Francisco Bay
23A1	Los Gatos Creek	Loma Prieta	NW, N		San Jose
23B	Berryessa Creek	Los Buellis Hills E of Milpitas	W, N		N part of Milpitas
23C	Silver Creek	N of Coyote	NW		Central San Jose
24	Charleston Slough	Palo Alto	NE		San Francisco Bay at Palo Alto
24A	Barron Creek	Los Altos Hills	NW, NE		Palo Alto
25	Matadero Creek	Los Altos Hills	NE		San Francisco Bay at Palo Alto
26	San Francisquito Creek	Santa Cruz Mountains N of Portola Valley	NE		San Francisco Bay at East Palo Alto
27	Colma Creek	San Miguel Hills in S Central San Francisco	S, SE		San Francisco Bay S of Point San Bruno
28	San Pedro Creek	Sweeney Ridge	W		S of Rockaway Beach

Key:

E East, easterly, eastern
S South, southerly, southern
N North, northerly, northern
W West, westerly, western

Notes:

[a] Marin County
[b] Santa Clara County
[c] Napa County

Peak Flows

Table SF-3 provides peak flow information in the San Francisco Bay Hydrologic Region and shows a correlation between significant flood events and peak flows.

- The most recent flooding occurred in the San Francisco Bay region in late 2005 and early 2006. This flooding resulted in peak flows on Sonoma and Coyote Creeks.
- The Napa River had the highest peak flow in the region (37,100 cfs) during the 1986 flood.

Table SF-3. Record Flows, San Francisco Bay Hydrologic Region

Stream	Location	Mean Annual Runoff (taf)	Peak Stage of Record (feet)	Peak Discharge of Record (cfs)	Date of Peak Discharge
Sonoma Creek	At Agua Caliente	53	32.5	20,300	12/31/2005
Napa River	Near St. Helena	68	23.6	18,300	12/31/2005
Napa River	Near Napa	155[b]	30.5[a]	37,100	2/18/1986
Alameda Creek	Near Niles	101[b]	14.8	29,000	12/23/1955
Arroyo de La Laguna	At Verona	552	22.6	11,400	1/5/1982
Coyote Creek[c]	Above Highway 237, at Milpitas	34	13.9[a]	2,550	1/24/2000
Coyote Creek[c]	Near Gilroy	35	13.8[a]	10,100	12/31/2005
Guadalupe River	Above Highway 101, at San Jose	57	14.6	6,070	12/16/2002

Key:
cfs = cubic feet per second taf = thousand acre-feet
Notes:
[a]Different date than peak discharge
[b]Most recent but less than period of record
The stations included in this table were selected from all USGS gauging stations in the hydrologic region, according to the following criteria:

- The watercourse must be a natural stream with a watershed of at least 100 square miles.
- The station must have a reasonably continuous record of discharge from 1996 to the present.
- The station must be far enough from other stations on the same river to reasonably represent a separate condition.
- Stations in well defined watercourse locations such as deep canyons are omitted, unless particularly important to the overall flood situation.

3.6.2 Historic Floods

Flood damage has been observed in the San Francisco Bay Hydrologic Region since at least 1861. The San Francisco Bay Hydrologic Region receives very little snow, so floodwaters originate primarily from intense rainstorms. The northern portion of the region receives more precipitation than the southern portion, and it floods more often. Flooding occurs most frequently in winter and spring. Most streams produce slow rise floods, but the steep terrain can cause flash floods that are intense and of short duration. Stream erosion and increased sediment from fire-damaged hillsides can lead to debris flows. Flooding at river mouths often occurs, and storm surges that coincide with high tides and high runoff can create severe coastal flooding in low-lying areas. Developed areas subject to sea level rise are a special concern. Continuing urbanization brings impervious surfaces subject to increasing local stormwater flooding. Structural facilities for managing flood risk and providing water storage that are present in the area have the potential produce structure failure floods. Tsunamis can also occur in the region but historically have caused little damage and are not listed as a major cause of floods in this region.

Although floods are predominantly slow rise, the shallow flooding associated with local stormwater runoff occurs often. Debris flows, coastal inundation, flash floods, and structure failures also cause damage at times. Table SF-4 presents an abridged summary of major floods in the region. For a more comprehensive list of flood events in the region, see Appendix B. Selected significant floods are briefly described below:

1861-62: The "Great Flood." A devastating flood inundated large areas of the West Coast, including places in the San Francisco Bay Hydrologic Region. For a week, there was no tidal inflow at the Golden Gate, only an outflow of river water 18 to 20 feet deep, floating on the salt water. Property was destroyed at many locations. On December 8, floodwaters in the town of Napa washed away houses. Napa flooded again on December 28 and again in January. The Guadalupe River flooded San Jose's downtown and the Alviso community.

Lower Guadalupe River, 1958

1958: During February-April 1958, several major rivers overflowed in the region, causing extensive damage. December 1958 again brought widespread flooding. Another levee failure on Alameda Creek destroyed crops and damaged industries and more than 225 homes in Niles (Fremont), Alvarado (Union City), and Alviso (San Jose). San Francisquito Creek overflowed, causing extensive damage in Palo Alto.

December 1981-April 1982. Record flooding occurred throughout the region. Debris flows caused three landslide-related fatalities, and most of the $18,464,000 damages in Marin County were due to landslides. In Napa County, houses were flooded in American Canyon, and the Napa River flooded vineyards in St. Helena. Contra Costa, Berkeley, Sausalito, Vallejo, Fairfield, San Rafael, and numerous other cities sustained flooding damage. Street flooding, mud flows, and attendant damage occurred to residential and commercial areas throughout the entire region.

November 1982-January 1983. Many Bay Area peninsula streams overflowed in January, including San Mateo, San Francisquito Creek, Coyote Creek, Napa River, and Barron Creek. . Mudslides closed local roads, flooded undercrossings, and damaged homes and infrastructure throughout the region. High tides flooded coastal areas, destroying homes, businesses, and oceanfront marinas in San Rafael, Corte Madera, Larkspur, San Antonio Creek, and Marin. Heavy rains, high winds, flooding, and levee breaks caused a total of $523,617,032 in damages regionwide.

February 1986, St. Valentine's Day Storm. Strong gusts coupled with high tides and heavy precipitation from the St. Valentine's Day storm caused streams to pool at their confluences with San Pablo Bay, flooding shoreline buildings and arterial roads. The Guadalupe River overflowed its east bank in San Jose, flooding residences and businesses. The Napa River flood caused three deaths in the Napa area, destroyed 250 houses, damaged another 2,500 houses, flooded downtown Napa, damaged 120 businesses, forced more than 5,000 residents to evacuate their homes, flooded a trailer park in Yountville, and caused an estimated $2 million in damage to vineyards. The Napa River floodwaters inundated several areas in the Napa County. Significant flooding also occurred in Sonoma, Solano, Vallejo, Contra Costa, and numerous other communities throughout the region.

Guadalupe River, 1986

December 2005-January 2006. Flooding on Corte Madera Creek caused more than $70 million in damages in the Corte Madera area. Losses estimated at $135 million were due to flood damage by the Napa River in Napa County.

Napa River Flood, 2006

Table SF-4. Selected Flood Events, San Francisco Bay Hydrologic Region

Date	Location	Flood Type	Description	County
December 1861-January 1862	Regionwide	Slow Rise	Severe storms occurred in the San Francisco Bay Area Region, causing what became known as the "Great Flood." For a week, there was no tidal inflow at the Golden Gate, only an outflow of river water 18 to 20 feet deep, floating on the salt water. The Guadalupe River flooded San Jose's downtown and the Alviso community.	Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, Sonoma
December 1931	Coyote Creek; Unincorporated Areas of Alameda County, Lower Guadalupe River, San Jose - Alviso, Milpitas - Alviso Roads, San Lorenzo Creek	Slow Rise, Flash	Major flooding of San Lorenzo Creek occurred in Alameda County. In Santa Clara County, there were moderate floods on Coyote Creek near Madrone on December 28, 1931.	Alameda, Santa Clara
April 1946	Regional coast	Tsunami	A tsunami that was recorded all along the California coast caused damages of $20,000 to houses and other property at Half Moon Bay. The tsunami traveled 1,000 feet inland.	Marin, San Mateo
December 1955 "1955 Christmas Flood"	Alameda Creek, Bay Area, Novato Creek, Corte Madera, Petaluma, San Rafael, Fairfax, Pescadero Creek, San Francisquito Creek, Coyote Creek, Stevens, Matadero, Guadalupe River, Russian River, Communities of Byron, Brentwood, Knightsen, Tree Haven, Fair Oaks, Meadow Homes, Sherman Acres, Gregory Gardens, City of Walnut Creek	Slow Rise, Structure Failure, Coastal	Widespread flooding occurred in December 1955. A levee failed on Alameda Creek, allowing floodwaters to inundate portions of Niles (Fremont), Centerville, Mission San Jose, Irvington, and Warm Springs. The City of Sonoma and Tubbs Island suffered damage from high flows on Nathanson Creek and Tolay Creek. San Francisquito Creek overflowed, causing extensive damage to Palo Alto.	Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, Sonoma
Feb-April 1958	San Francisco Bay Area, Corte Madera Creek, San Francisquito Creek, Penitencia Creek, Guadalupe River, San Tomas Aquinas Creek, Stevens Creek, Permanente Creek, Matadero Creek, Russian River, Guadalupe River, Las Trampas Creek, San Ramon Creek, Marsh Creek, Coyote Creek	Debris Flow, Coastal, Slow Rise, Engineered Structure Failure	Las Trampas Creek and San Ramon Creek overflowed down the main street of the city of Walnut Creek. Marsh Creek washed out a county bridge. Arroyo Valle washed out the Southern Pacific Railroad bridge in Pleasanton. Levees failed on the Guadalupe River and Coyote Creek, inundating Alviso.	Alameda, Contra Costa, Marin, San Mateo, Santa Clara, Solano, Sonoma, San Francisco, Santa Clara

Table SF-4. Selected Flood Events, San Francisco Bay Hydrologic Region

Date	Location	Flood Type	Description	County
1958	Corte Madera Creek, Alameda Creek, Niles, Alvarado, Alviso, San Francisquito Creek, Palo Alto, Pinole	Slow Rise	Corte Madera Creek flooding damaged San Anselmo, Ross, Kentfield, Larkspur, Fairfax, and vicinity numerous times, notably in 1958. Floods breached a levee, destroying crops and damaging industries and more than 225 homes in Niles, Alvarado, and Alviso. The same year, San Francisquito Creek overflowed, causing extensive damage to Palo Alto. Flooding in the business district and a residential subdivision in Pinole occurred in 1958, as well as flooding of residences and business establishments in Rodeo.	Alameda, Contra Costa, Marin, Santa Clara
May 1960	Regional coast, Novato Creek, Corte Madera Creek, Half Moon Bay	Tsunami	A tsunami that was recorded throughout the West Coast damaged boats at San Rafael and interrupted ferry service. A tsunami recorded all along the West Coast damaged boats at San Rafael and interrupted ferry service. Half Moon Bay had three near drownings, along with much flooding and boat damage.	Marin, San Francisco, San Mateo
December 1962-February 1963	Corte Madera Creek, Northern and Central California (Sonoma to San Francisco), Russian River, Guadalupe River, Napa River; Napa, Alviso, Delta: Van Sickle Island	Flash, Slow Rise, Stormwater	The Napa River flooded downtown Napa and residences and caused an estimated $5.5 million in damages. Damage occurred to public works at Alviso. Morgan Hill, Agnew, and Alviso flooded, causing damage and leaving debris deposits.	Alameda, Contra Costa, Marin, Napa, Solano, Sonoma, Santa Clara
March 1964	Regional coast	Tsunami	A tsunami resulted from the March 1964 earthquake in Alaska. The tsunami had waves between 10 and 20 feet high along parts of the California, Oregon, and Washington coasts. The damages in California amounted to $32 million (calculated in 1983 dollars), with the bulk of the costs incurred in Crescent City where 11 of the 13 California deaths occurred.	Marin, San Francisco, San Mateo
December 1968 – February 1969 Winter Storms	San Francisco Bay area, Elk River, Gualala River, Corte Madera Creek, Pajaro River, Salinas River, San Lorenzo River, Guadalupe River, Grizzly Island	Coastal, Slow Rise	Storms, caused flooding in Solano, Contra Costa, Sonoma, and Marin counties. Total damages were approximately $300 million. In January and February 1969, high tides and adverse wave action in the Delta area combined with large river inflow and rain-soaked levees caused the flooding of several islands and the endangerment of many other islands. Approximately 11,400 acres were inundated, and flood damages amounted to approximately $9.2 million.	Alameda, Contra Costa, Marin, Santa Clara, Solano, Sonoma

Table SF-4. Selected Flood Events, San Francisco Bay Hydrologic Region

Date	Location	Flood Type	Description	County
December 1981-April 1982	San Francisco Bay Area, Penitencia Creek, Los Gatos Creek, Llagas Creek, San Francisquito Creek, Uvas Creek, City of Petaluma - Payran Ranch	Slow Rise, Flash, Debris Flow, Coastal, Stormwater	Damage in Alameda County was concentrated in Oakland, Piedmont, and Berkeley. Damage in Contra Costa County was concentrated in the areas of Richmond, El Sobrante, El Centro de Libertad, Martinez, Orinda, Walnut Creek, and Lafayette. Most landslides in San Francisco County were located in the center of the city in the Twin Peaks, Mount Davidson, and Glen Canyon Park areas. According to the USACE, floods in 1982 caused damage in the City of Petaluma, particularly in the Payran Ranch area. Damage in Marin County was concentrated in the southeastern part of the county between Sausalito and Fairfax. San Mateo County during the weeks before the storm revealed that a few debris flows had been triggered by storms during late December.	Alameda, Contra Costa, Marin, Napa, San Mateo, Santa Clara, Sonoma, Solano
November 1982-March 1983	Corte Madera Creek, Coyote Creek, Guadalupe River, Penitencia Creek, Calabazas Creek, Los Gatos Creek, San Anselmo, Napa River	Slow Rise, Debris Flow, Coastal, Stormwater, Engineered Structure Failure	Record flooding on Corte Madera Creek damaged San Anselmo, Ross, Kentfield, and Larkspur. Severe floods occurred on Coyote Creek in the Alviso area of San Jose, causing more than $6 million in damages. Guadalupe River and Calabasas Creek experienced overbanking, and Coyote-Alamitos Canal experienced flooding that caused damage to homes and businesses in San Jose, Cupertino, and Sunnyvale. Properties were damaged in San Jose and Milpitas as a result of flooding from Coyote Creek, Berryessa Creek, Lower Penitencia Creek, Upper Penitencia Creek, Los Coches Creek, and Sweigert Creek. Floodwaters from Coyote Creek inundated farmland. The largest of the Petaluma Creek sheet flow floods occurred in some or all of the Denman Flat, Lynch Creek, and Payran floodplain areas, causing about $28 million in damages plus damaging Petaluma's wastewater treatment plant.	Alameda, Contra Costa, Marin, Napa, San Mateo, Santa Clara, Solano, Sonoma
February 1986 "St. Valentine's Day Storm"	City of Petaluma - Payran Ranch, Marin, Napa River, Nathanson Creek, Guadalupe River, Calabazas Creek, San Tomas Creek, Ross Creek, Guadalupe Creek, Los Gatos Creek, Upper Penitencia Creek, Llagas Creek, Uvas Creek, Corrallitos Creek, Corte Madera Creek	Slow Rise, Coastal	Strong gusts coupled with high tides and heavy precipitation from the St. Valentine's Day storm caused streams to pool at their confluences with San Pablo Bay in 1986, flooding shoreline buildings and arterial roads. The Napa River floodwaters inundated several areas in Napa County. According to the USACE, floods in 1986 caused damage in the City of Petaluma, particularly in the Payran Ranch area. Significant flooding also occurred on Nathanson Creek in Sonoma. The Guadalupe River flooded San Jose's downtown and Alviso community. Floodwaters overbanked creeks, including Upper Penitencia Creek in the east, and Llagas Creek, Uvas Creek and, Corrallitos Creek in the south, which flooded homes and farmlands.	Contra Costa, Marin, Napa, Santa Clara, Sonoma

Table SF-4. Selected Flood Events, San Francisco Bay Hydrologic Region

Date	Location	Flood Type	Description	County
January – March 1995 "Christmas Storm"	Napa River, Guadalupe River, Los Gatos Creek, Llagas Creek, Upper Penitencia Creek, Coyote Creek, Pacheco Creek, San Francisco Bay	Slow Rise, Flash, Stormwater	Most of the storms hit the Sacramento River Basin, which resulted in small-stream flooding due to drainage system failures. The Guadalupe River overflowed in January and March, damaging downtown San Jose and Alviso. Stormwater damaged the San Francisco storm drain/sewer system. High water in Los Gatos Creek flooded about 300 homes and businesses and caused $10 million in damages.	Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, Sonoma
December 1996-January 1997	San Francisco Bay Area, Guadalupe River, Llagas Creek, Coyote Creek	Coastal, Debris Flow, Flash, Stormwater	300 square miles were flooded, including the Yosemite Valley. Over 120,000 people had to be evacuated in northern California. Several levee breaks were reported across the Sacramento and San Joaquin Valleys. Over 23,000 homes and businesses, agricultural lands, bridges, and roads were damaged.	Alameda, Contra Costa, Marin, Napa, San Francisco, Santa Clara, San Mateo, Solano, Sonoma
February 2000	Russian River, Daly City, SFO	Flash, Debris Flow	Widespread rain with 24-hour accumulation of more than 5 inches occurred over the area on February 13 into February 14 caused flash flooding.	Contra Costa, Marin, Santa Clara, San Francisco, San Mateo, Sonoma
December 2002	Napa River, Guadalupe River	Slow Rise, Flash, Debris Flow	Floodwaters from the Napa River invaded 100 structures and caused an estimated $1 million in damages.	Napa, Solano, Santa Clara
December 2005 - January 2006 New Year's Eve Flood	San Francisco Bay Area, Corte Madera, San Anselmo Creek, Napa River, Nathanson Creek, Sonoma Creek, Sonoma Creek, Petaluma River, Walnut Creek, Richmond, San Pablo, Martinez, Orinda	Flash, Debris Flow, Stormwater	Sonoma Creek flooding damaged a mobile home park, bridge, and pipeline. Nathanson Creek flooded 27 classrooms at Sonoma Valley High School. Flooding on Corte Madera Creek caused more than $70 million in damages in the Corte Madera area. Losses estimated at $135 million were due to flood damage by the Napa River in Napa County.	Alameda, Contra Costa, Marin, Napa, San Mateo, Solano, Sonoma
March 2011	Berkeley, Point Reyes, Sausalito, San Francisco	Tsunami	A 4.4-foot tsunami at Point Reyes struck coastal areas of the region, causing minor damage to boats and infrastructure, particularly at Berkeley Marina.	Alameda, Marin, San Francisco, San Mateo
December 2012	San Francisquito	Flash	Rainstorms caused the temporary evacuation of about 36 people. Dozens returned home after East Palo Alto flooding. Floodwater impacted northbound Highway 101. A levee was breached on the San Mateo side of San Francisquito Creek, which caused localized flooding in Palo Alto.	San Mateo

3.6.3 History of Flood Response

In the San Francisco Bay Hydrologic Region the major types of flooding include coastal, slow rise, stormwater and tsunami flooding. As a result of and in response to the regionally specific flooding, a number of traditional flood management projects have been developed. These include a series of reservoirs and construction of channels and levees.

Flood Management Infrastructure

The San Francisco Hydrologic Region has extensive flood management infrastructure, including floodwater storage facilities and channel improvements partially funded and/or cosponsored by State and Federal agencies. Flood management reservoirs in the region include Lake Chesbro on Llagas Creek and Lake Del Valle on Arroyo Valle, and one smaller reservoir on Cull Creek. Flood management agencies are responsible for operating and maintaining approximately 2,700 miles of levees, more than 186 dams, 43 debris basins, and other facilities within the San Francisco Hydrologic Region; however, not all of these are dedicated for flood management or have flood storage. For a comprehensive list of major infrastructure, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

Lower Guadalupe River, 1931

Flood Management Governance

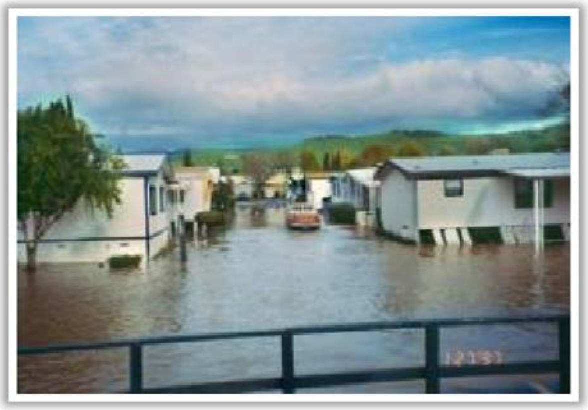
Although primary responsibility for flood management might be assigned to a specific local entity in the San Francisco Hydrologic Region, aggregate responsibilities are spread among more than 140 agencies with many different governance structures. Some of the larger agencies in the San Francisco region include the following:

- Alameda County Flood Control and Water Conservation District
- Contra Costa County Flood Control and Water Conservation District
- Marin County Flood Control and Water Conservation Agency
- Napa County Flood Control and Water Conservation District
- San Francisco Department of Public Works
- San Mateo County
- Santa Clara Valley Water District
- Solano County Water Agency
- Sonoma County Water Agency

For a comprehensive list of the entities that have responsibilities or involvement in flood and water resources management, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering)*.

Flood-Related Regulations

Several agencies within the region have implemented regulations that directly impact flood management and local use within floodplains. Alameda County has designated floodways on Cull Creek, Crow Creek, Alameda Creek, and Arroyo de la Laguna. This limits what can be constructed within the floodways for a specific designed storm event (e.g., 100-year event). Napa County has a designated floodway on the Napa River, and Sonoma County has designated floodways on Sonoma Creek and San Antonio Creek. Marin County has a designated floodway on Novato Creek.



Coyote Creek Flooding, 1997

All counties in the San Francisco Bay Hydrologic Region have ordinances regulating floodplain development; these counties include Marin, Sonoma, Napa, Solano, San Francisco, Contra Costa, San Mateo, Alameda, Santa Clara, and Santa Cruz counties. Additionally, local land use jurisdictions have adopted floodplain management ordinances, identifying 100-year floodplains and floodways to qualify for participation in FEMA's NFIP.

Flood Emergency Planning Efforts

Emergency management is a significant concern in the San Francisco Bay Hydrologic Region due to the risk of coastal and tsunami flooding; therefore, many emergency management plans have been developed. These include plans from Vallejo Sanitation and Flood Control District, the City of Napa, and Solano County Water Agency.

The City of Napa has a system of road closures, adopted in 2003, based on the stage of the Napa River, which reduces risk to individuals and property in the event of a flood. Solano County Water Agency provides a flood awareness manual that gives guidelines to citizens for appropriate planning and response behaviors for floods. The county offers small grants for construction of flood management infrastructure.

Multi-Hazard Mitigation Plans. FEMA-approved MHMPs were identified or collected for Contra Costa, Marin, Napa, San Francisco, Santa Clara, San Mateo, Solano, and Sonoma counties. For a list of FEMA-approved MHMPs with corresponding dates of approval, refer to Appendix D. Other risk assessment studies were prepared by various entities, including USACE, FEMA, and the State Reclamation Board of California. For a comprehensive list of risk assessment studies, refer to *Attachment G: Risk Information Inventory*.

Flood Insurance. FEMA has provided FIRMs for all areas within the region. FIRMs in seven of the region's eight counties were prepared after 2008. San Francisco City and County currently are not scheduled for update. Four counties and 24 cities and towns in the San Francisco Bay Hydrologic Region participate in the CRS. Table C-4 is a comprehensive list of participants in the CRS system.

3.6.4 Current Flood Management

In the San Francisco Hydrologic Region, 138 local and USACE flood management projects or planned improvements were identified. One hundred nineteen of these projects have costs totaling nearly $3.38 billion. Of 138 projects, 54 projects use an IWM approach, totaling more than $1 billion.

Lower Las Gallinas and Miller Creek Restoration Project

Because an IWM approach offers an overall flood management strategy for long-term economic stability, public safety, and enhancement of environmental stewardship, DWR and USACE support that approach as the future of flood management in California. An example of a local project with an IWM approach is the Lower Las Gallinas and Miller Creek Restoration Project, which will integrate wetland restoration with flood management benefits, including levee rehabilitation, local drainage improvements, and channel dredging. For a comprehensive list of these projects, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings).*

In addition, DWR administers the IRWM Grant Program. This program has supported the development of five IRWM Plans that encompass the San Francisco Hydrologic Region, the following four of which specifically address flood control.

- Solano Water Agency IRWM Plan, adopted in 2005, lists no flood control infrastructure to be constructed in the near term; however, it does discuss updating its flood control plan and flood hazard maps, establishing more clearly its flood control duties with other agencies, and evaluating the safety of its major structures, such as Monticello Dam, which impounds Lake Berryessa (Solano Agencies, 2005).
- Bay Area IRWM Plan, 2006, discusses flooding in depth; 48 flood control projects are identified, with 22 short-term projects providing direct flood control benefits (Jones & Stokes et al., 2006).
- *East Contra Costa County IRWM Plan*, adopted in 2006, emphasizes the relationship of flood control and ecosystem benefits, and identifies eight flood control projects (City of Antioch et al., 2006).
- *Tomales Bay Watershed Integrated Coastal Water Management Plan*, 2007, prioritized projects for the region (Tomales Bay Watershed Council, 2007).

3.7 San Joaquin River Hydrologic Region

3.7.1 Regional Setting

The San Joaquin River Hydrologic Region includes the northern portion of the San Joaquin Valley and extends from the crest of the Coast Ranges on the west to the crest of the Sierra Nevada on the east, and from the Delta to the upper San Joaquin River watershed in the north-south direction. The San Joaquin River Hydrologic Region includes approximately 70 percent of the Delta land area. All drainage is northward to the Delta in the San Joaquin River. The principal tributaries originate in the Sierra Nevada, with only a few significant streams coming from the west.

The flatter portions of the streams in the San Joaquin Valley are prone to frequent slow rise flooding, which accounts for about half of all floods. The more damaging floods are usually caused by spring snowmelt. The flatness of the valley floor contributes to the areal extent of these floods. Flooding in the mountainous upper watersheds is rarer due to well developed watercourses, but floods can still occur, especially in intermontane valleys. Coastal-type flooding of low-lying Delta islands recurs often, as does structural failure of Delta levees, many of which were constructed without benefit of modern engineering. Many cities on the valley floor sustain stormwater flooding arising from moderate runoff and inadequate channel or roadway slopes. Infrequently, a flash flood or a debris flow occurs.

More than 535,000 people and around $40 billion in structures are exposed to the 500-year flood event in the San Joaquin Hydrologic Region. Also, more than $1.9 billion in agriculture crop value is exposed. Over 260 plant and animal species that are State- or Federally listed as threatened, endangered, or rare are exposed to flood hazards in the region. Table SJ-1 provides a snapshot of people, structures, crops, infrastructure exposed to flooding in the region.

Table SJ-1. San Joaquin River Hydrologic Region Exposures within the 100-Year and 500-Year Floodplains

Segment Exposed	100-year (1%) Floodplain	500-year (0.2%) Floodplain
Population (% total exposed)	157,100 (9%)	535,300 (31%)
Total Depreciated Replacement Value of Exposed Structures and Contents	$11.3 billion	$39.6 billion
Exposed Crop Value	$1.4 billion	$1.9 billion
Exposed Crops (acres)	682,100	878,700
Tribal Lands (acres)	3	3
Essential Facilities (count)	93	298
High Potential-Loss Facilities (count)	92	134
Lifeline Utilities (count)	12	29
Transportation Facilities (count)	646	901
Department of Defense Facilities (count)	2	2
Plant species State- or Federally listed as Threatened, Endangered, or Rare[a]	130	131
Animal species State- or Federally listed as Threatened, Endangered, or Rare[a]	131	131

Note:
[a]Many Sensitive Species have multiple occurrences throughout the state, and some have very large geographic footprints that may overlap more than one analysis region. As a result, a single Sensitive Species could be counted in more than one analysis region. Because of this, the reported statewide totals will be less than the sum of the individual regions.

The San Joaquin River is the principal river in the hydrologic region, and all other streams in the region are tributary to it. Tributary streams and rivers include Fresno, Chowchilla, Merced, Tuolumne, Stanislaus, Mokelumne, and Cosumnes rivers. Major lakes and reservoirs in the San Joaquin River Hydrologic Region include Hensley Lake, Eastman Lake, Lake McClure, New Don Pedro Lake, New Melones Lake, Camanche Reservoir, Millerton Lake, and Jenkinson Lake. Major cities in the hydrologic region include Merced, Modesto, and Stockton. There are five major rivers, seven lesser rivers, and numerous creeks. Figure SJ-1 illustrates the location of major features in the region, including streams and rivers.

This region experiences a wide range of precipitation that varies from low rainfall amounts on the valley floor to extensive snowfall in the higher elevations of the Sierra Nevada. The snow that remains after winter serves as stored water before it melts in the spring and summer. The average annual precipitation of several Sierra Nevada stations is about 35 inches.

Stream Descriptions

Table SJ-2 includes a detailed description of each watercourse in the San Joaquin River Hydrologic Region. The table begins with the San Joaquin River and proceeds upstream, listing its tributaries and distributaries, with secondary tributaries listed following each primary tributary. Distributaries, shown in italics, (including bypasses and diversions) are listed at the point of diversion and not listed where they enter another listed stream. Mormon Slough is a distributary with a tributary stream of its own. Indentation and sub-letters and numbers indicate tributary status.

San Joaquin River Flood, 1997

San Joaquin River Rivers

Figure SJ-1 Rivers and Streams of the San Joaquin River Hydrologic Region

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

Table SJ-2. Stream Descriptions, San Joaquin River Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
SAN JOAQUIN RIVER STREAM SYSTEM					
1	San Joaquin River	Sierra Nevada crest SE of Yosemite National Park	SW, W, NW	Millerton	Sacramento River in Suisun Bay
1A	Marsh Creek	E slope of Mount Diablo	NW, E, N	Marsh Creek Debris Reservoir	Big Break near Oakley
1A1	Sand Creek	NE slope of Mount Diablo	E		NW of Brentwood
1A2	Deer Creek[a]	NE slope of Mount Diablo	E		W of Brentwood
1A3	Dry Creek[b]	Deer Valley	E		SW of Brentwood
1B	Mokelumne River	Sierra Nevada crest in Alpine and Calaveras Counties	SW, W	Camanche Reservoir	West of Lodi near Voorman's Landing
1B1	Cosumnes River	Iron Mountain Ridge E of Placerville	SW		Near Thornton
1B1a	Badger Creek	E Sacramento County S of Wilton	SW		S of Elk Grove
1B1b	Deer Creek[c]	Sierra Nevada foothills W of Placerville	SW		SE of Elk Grove
1B2	Dry Creek[d]	N slopes of Shake Ridge	SW		W of Thornton
1B3	N Fork Mokelumne River	Crest of Sierra Nevada at Folger Peak	N, W, SW		Sierra Nevada foothills S of Volcano
1C	Old River	West of Lathrop	W, N		San Joaquin River NE of Franks Tract
1C1	Indian Slough	NW corner of Discovery Bay	E		NE of Discovery Bay
1C1a	Kellogg Creek	N of Livermore	N, E	Kellogg Creek Debris Reservoir	NE corner of Discovery Bay
1C2	Tom Paine Slough	W of Banta	NW		N of Tracy
1C3	Paradise Cut	SE of Mossdale	NW		NE of Tracy
1D	Disappointment Slough	NW of Stockton	W		S of Empire Tract
1D1	Bear Creek[e]	W of Valley Springs	W, SW		NW of Stockton
1D1a	Mosher Creek (Mosher Slough)	N of Linden	W		NW of Stockton
1E	Calaveras River	Central Sierra Nevada E of San Andreas	W, SW	New Hogan Lake	W part of Stockton
1E1	Stockton Diverting Canal	NE part of Stockton	NW		E of Stockton

Table SJ-2. Stream Descriptions, San Joaquin River Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
SAN JOAQUIN RIVER STREAM SYSTEM					
1E2	Mormon Slough	W of Bellota			San Joaquin River E of Port of Stockton
1E2a	Potter Creek	Several parts NE of Stockton			NE part of Stockton
1F	French Camp Slough	E of French Camp	NW		Port of Stockton
1F1	Walker Slough	S of Stockton	W		S of Stockton
1F1a	Duck Creek	SW of Milton	SW		S of Stockton
1F2	Littlejohns Creek	NW of Knights Ferry	W	Farmington Reservoir	E of French Camp
1F2a	Lone Tree Creek	N of Oakdale	W		E of French Camp
1G	Stanislaus River	Sierra Nevada crest in Alpine County	SW	New Melones Lake	W of Modesto
1H	Tuolumne River	Sierra Nevada crest in E Yosemite National Park	W, SW, W	New Don Pedro Reservoir	N of Grayson
1I	Del Puerto Creek	E slope of Red Mountain	NE		NW of Patterson
1J	Salado Creek	Mikes Peak	NE		NE of Patterson
1K	Orestimba Creek	SW slope of Wilcox Ridge	NW		N of Newman
1K1	Crow Creek	NW of Wilcox Ridge	NE		SE of Crows Landing
1L	Merced River	Cathedral Range in the Sierra Nevada	SW	Lake McClure	NE of Newman
1L1	Canal Creek	Table Top Mountain	SW	Canal Creek Flood Detention Reservoir	N of Livingston
1M	Los Banos Creek	Coast Range crest at Peckham Ridge	NE, E, N	Los Banos Reservoir	E of Newman
1M1	Garzas Creek	Coast Range crest E of Mustang Peak	E		SE of Gustine
1M1a	Mustang Creek	SW of Gustine	NE	Mustang Creek Retarding Structure	SW of Gustine
1N	Eastside Bypass	W of Madera	NW		W of Merced
1N1	Bear Creek[f]	NW slope of Guadalupe Mountains	SW	Bear Creek Flood Detention Reservoir	S of Livingston
1N1a	Black Rascal Creek	China Hat NE of Merced	SW		S of Atwater
1N1b	Burns Creek	S of Lake McClure	SW	Burns Creek Flood Detention Reservoir	N of Planada

Table SJ-2. Stream Descriptions, San Joaquin River Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
SAN JOAQUIN RIVER STREAM SYSTEM					
1N2	Owens Creek	SW slope of Guadalupe Mountains	SW	Owens Creek Flood Detention Reservoir	SW of Atwater
1N2a	Miles Creek	W of Stonehouse	SW		SW of Merced
1N3	Mariposa Bypass	NE of Los Banos	W		San Joaquin River N of Los Banos
1N4	Duck Slough	Near Le Grand	SW		NE of Los Banos
1N4a	Mariposa Creek	NE slope of Guadalupe Mountains	S, SW	Mariposa Creek Flood Detention Reservoir	Near Le Grand
1N5	Chowchilla River	S of Chowchilla Mountains	S, SW	Eastman Lake	W of Red Top
1N5a	Ash Slough	N of Madera	S, SW	Eastman Lake	Eastside Bypass S of Red Top
1N5b	Berenda Slough	N of Madera	S, SW	Eastman Lake	Eastside Bypass W of N Madera
1N6	Fresno River	N and W of Bass Lake	S, W		W of central Madera
1O	Fresno Slough	N Fork Kings River S of Riverdale	NW		Mendota Pool
1O1	Panoche Creek	Coast Range crest at Panoche Pass	SE, NE		Mendota Pool
1O2	James Bypass	N of Helm	NW		N of Tranquility
1P	Chowchilla Canal Bypass	W of Mendota	N		Eastside Bypass W of S Madera

Key:

E East, easterly, eastern
N North, northerly, northern
S South, southerly, southern
W West, westerly, western

Notes:

a Contra Costa County
b Contra Costa County
c Sacramento and El Dorado Counties
d Along Sacramento/San Joaquin County Line and Amador County
e San Joaquin and Calaveras Counties
f Merced and Mariposa Counties

Peak Flows

Table SJ-3 presents the peak flows in the San Joaquin River Hydrologic Region and shows a correlation between significant flood events and peak flows.

- The highest peak discharge was recorded in 1997 on Cosumnes River.
- Five streams in the San Joaquin River region had record peak discharges of more than 50,000 cfs.

Table SJ-3. Record Flows, San Joaquin River Hydrologic Region

Stream	Location	Mean Annual Runoff (taf)	Peak Stage of Record (feet)	Peak Discharge of Record (cfs)	Date of Peak Discharge
Del Puerto Creek	Near Patterson	6	14.9	5,270	2/3/1998
James Bypass	Near San Joaquin	215[e]	N/A	5,570[d,e]	6/7/1969
Merced River	At Pohono Bridge, near Yosemite	454	23.4	24,600	1/3/1997
Merced River	Near Stevinson	N/A	73.8	13,600	12/5/1950
Merced River	Below Merced Falls Dam, near Snelling	1,003[b]	12.4	9,360	6/1/1969
Mokelumne River	At Woodbridge	403[b]	23.3[a]	5,340	3/8/1996
Orestimba Creek	Near Newman	13	9.5	12,000	3/10/1995
Panoche Creek	At Interstate 5, near Silver Creek	N/A	13.5	9,940	2/3/1998
San Joaquin River	Near Vernalis	3,308	34.9[a]	79,000	12/9/1950
San Joaquin River	Below Friant	663[b]	23	60,300	1/3/1997
San Joaquin River	Near Newman	1,271	66.3[a]	36,200	1/28/1997
San Joaquin River	At Fremont Ford Bridge	556[b]	71.6	23,000	4/8/2006
San Joaquin River	Near Mendota	691	16.6[a]	11,700	6/20/1941
Stanislaus River	At Ripon	707	63.3	62,500	12/24/1955
Stanislaus River	Below Goodwin Dam, near Knights Ferry	564[b]	28.9	40,200	12/24/1955
Tuolumne River	Below La Grange Dam, near La Grange	751	28.4	58,900	1/3/1997
Tuolumne River	At Modesto	985	71.2[a,c]	57,000	12/9/1950

Key:
cfs = cubic feet per second   ft = feet   N/A = not available
taf = thousand acre-feet

Notes:
[a]Different date than peak discharge.
[b]Most recent but less than period of record.
[c]Due to backwater.
[d]Maximum Daily Mean. No flow for all or most of each year.
[e]2006 record, most recent available.

The stations included in this table were selected from all USGS gauging stations in the hydrologic region, according to the criteria:

- The watercourse must be a natural stream with a watershed of at least 100 square miles.
- The station must have a reasonably continuous record of discharge from 1996 to the present.
- The station must be far enough from other stations on the same river to reasonably represent a separate condition.
- Stations in well defined watercourse locations such as deep canyons are omitted, unless particularly important to the overall flood situation.

3.7.2 Historic Floods

Flood damage has been observed in the San Joaquin Hydrologic Region since at least 1805. Floods can be caused by heavy rainfall; by dams, levees, or other engineered structures failing; or by extreme wet-weather patterns. Floods in the San Joaquin River Hydrologic Region originate principally from melting of the Sierra snowpack and from rainfall. Flooding from snowmelt typically occurs in the spring and has a lengthy runoff period. Flooding from rainfall occurs in the winter and early spring, particularly when storms arriving from the Gulf of Alaska draw moisture-laden air from the tropics. This pattern is known as an Atmospheric River. When this type of storm occurs during the spring months, it can increase spring snowmelt and runoff in the Sierra and overcome flood management facilities.

Slow rise flooding is the predominant cause of flood damage in the San Joaquin River region. Flooding of Delta islands recurs often and may be a coastal-type phenomenon caused by high tides, high winds, or structure failure. Other types of flooding occur occasionally, including stormwater flooding. Flood damage has been observed in the San Joaquin River Hydrologic Region since at least 1805. Table SJ-4 presents an abridged synopsis of flood events in the region. For a more comprehensive list of flood events in the San Joaquin Hydrologic Region, see Appendix B. Selected significant floods are briefly described below.

1861-62: The "Great Flood." The "Great Flood" was remarkable for the exceptionally high stages reached on most streams, repeated large floods, and prolonged and widespread inundation in the San Joaquin Valley.

November-December 1950. Snowmelt flood was documented, with the most damage, countywide, occurring in November and December of 1950. The west levee of Paradise Cut breached, causing Delta flooding on the Pescadero Tract and the Stewart Tract, and washing out the Southern Pacific Railway tracks and State Highway 50 west of Stockton. Levees breached and flooded 3,220 acres on Venice Island and 5,490 acres on Webb Tract. Hardest hit were Merced, Chowchilla, Centerville, Visalia, Porterville, Oildale, Isabella, and Kernville.

Flooded Residential Neighborhood in Stockton, 1955

December 1955-January 1956. Heavy rainfall and snowmelt occurred in the upper watersheds of the eastside tributaries to the San Joaquin River, causing extensive flooding along the river and its major tributaries on the east side, as well as flooding on the larger tributaries on the west side. This flood caused extensive damage to agriculture, homes, and public facilities. Unusually high tides aggravated the situation by impeding the passage of floodwater through the Delta.

February-April 1958. The Cosumnes River and Deer Creek overflowed, damaging lands and scattering buildings from Sloughhouse to the Mokelumne River. Levees breached and flooded 13,499 acres on Canal Ranch Tract, Shin Kee Tract, and Terminous Tract.

December 1964-January 1965. Major flooding and substantial damages occurred along the Stanislaus and Cosumnes rivers, Deer Creek, and Dry Creek. The flood of December 1964 is the largest recorded flood along the Mokelumne River; however, due to the completion of Camanche Dam in early 1964, damage was limited to several thousand dollars.

December 1968-February 1969. Severe rain caused floods that struck the northern part of the region, and both rain and snowmelt caused floods in the southern part of the region.

October 1982-March 1983. In January, Orestimba, Crow, Salado, and Del Puerto creeks overflowed and flooded small communities. A levee breached and flooded about 1,200 acres in an area between the Mokelumne River and Dry Creek southwest of Galt. The levee at Venice Island breached and flooded 3,220 acres of farmland. More than 16,000 acres were flooded, and the estimated associated damages amounted to more than $20 million.

San Joaquin River Flooding, 1997

December 1996-January 1997. Fourteen levee breaches occurred on the San Joaquin River between Fresno and the Chowchilla Bypass, inundating agricultural lands, including many vineyards north of the river. Amador County was seriously impacted by heavy rain, heavy snow, utility disruption, and related storm damage that began on December 20, 1996. Don Pedro Dam overtopped. In January 1997, the Merced River ran over its banks and inundated most of Yosemite Valley and areas downstream to the Merced County line. The Flood of January '97 caused flooding in the San Joaquin Valley, as well as the adjacent foothills. Numerous houses adjacent to the San Joaquin River flooded, while agricultural lands near the Merced River were inundated. Statewide damage estimates included $1.8 billion and 8 fatalities..

Jones Tract Levee Breach, 2004

June 2004. The Lower Jones Tract levee failed, inundating the 5,894-acre island. Levee breaks flooded agricultural areas in western portions of San Joaquin County.

Table SJ-4. Selected Flood Events, San Joaquin River Hydrologic Region

Date	Location	Flood Type	Description	County
1805	Mokelumne River	Slow Rise	Native American legends and journals of Spanish explorers and early settlers record widespread flooding in the county.	San Joaquin
December 1861-January 1862 "The Great Flood"	Statewide	Slow Rise	The "Great Flood" was remarkable for the exceptionally high stages reached on most streams, the repeated large floods, and the prolonged and widespread inundation in the San Joaquin Valley.	Statewide
March 1907	San Joaquin River Hydrologic Region	Slow Rise	Only a moderate rise on the upper San Joaquin River was observed during this flood, but there were exceptionally high stages on the large tributaries in the lower part of the basin.	Amador, Contra Costa, Sacramento, San Joaquin
1909	Mokelumne River	Slow Rise	The San Joaquin River Hydrologic Region experienced urban and small-stream flooding.	Alpine, Amador, Calaveras, Contra Costa, El Dorado, Fresno, Madera, Mariposa, Merced, Sacramento, San Joaquin, Stanislaus, Tuolumne
December 1937	Mokelumne River, Yosemite Valley	Slow Rise	The Merced River flooded the lower portions of the valley, and the highway and Yosemite Valley Railroad were materially damaged. Other damage occurred in low-lying areas of the San Joaquin River.	Mariposa, San Joaquin
February-March 1938	Fresno River, Mokelumne River, Delta: Mandeville, Quimby, Rhode, Venice Island, Pescadero, Stewart Tracts	Slow Rise, Engineered Structure Failure	Delta levees breached on Mandeville, Quimby, Rhode, and Venice Islands and on Pescadero and Stewart Tracts, flooding about 21,000 acres. The 100-acre Rhode Island Tract was never reclaimed.	Contra Costa, Madera, San Joaquin, Stanislaus
December-November 1950	Carson River Basin, Fresno River, San Joaquin Valley, Stockton, Merced, Chowchilla. Delta: Mossdale, Pescadero, Stewart Tracts, Delta: Venice Island, Webb Tract: Mokelumne River; Stanislaus River	Slow Rise, Stormwater, Structure Failure	The west levee of Paradise Cut breached, causing Delta flooding on the Pescadero Tract and the Stewart Tract. Flooding washed out the Southern Pacific Railway tracks and State Highway 50 west of Stockton. Levees breached and flooded 3,220 acres on Venice Island and 5,490 acres on Webb Tract.	Alpine, Amador, Calaveras, Contra Costa, Fresno, Madera, Merced, San Joaquin, Stanislaus, Tuolumne
December 1955-January 1956 "1955 Christmas Flood"	Regionwide	Slow Rise, Engineered Structure Failure	Heavy rainfall and snowmelt occurred in the upper watersheds of the east-side tributaries to the San Joaquin River. Levees breached and flooded 769 acres on Quimby Island, 3,430 acres on Empire Tract, and 9,300 acres on New Hope Tract.	Alameda, Alpine, Amador, Contra Costa, Calaveras, El Dorado, Fresno, Madera, Mariposa, Merced, Sacramento, San Joaquin, Stanislaus, Tuolumne
February-April 1958	Regionwide	Slow Rise, Stormwater, Structure Failure	The Cosumnes River and Deer Creek overflowed, damaging lands and buildings scattered from Sloughhouse to the Mokelumne River. The State declared disasters CD 82-DR-CA and CD 82-DR-CA. Levees breached and flooded 13,499 acres on Canal Ranch Tract, Shin Kee Tract, and Terminous Tract.	Alpine, Amador, Calaveras, Contra Costa, El Dorado, Fresno, Madera, Mariposa, Merced, Sacramento, San Joaquin, Stanislaus, Tuolumne

Table SJ-4. Selected Flood Events, San Joaquin River Hydrologic Region

Date	Location	Flood Type	Description	County
December 1962-February 1963	Regionwide	Slow Rise	Flood damage to agricultural and public facilities was particularly serious along the streams flowing from west-side tributaries.	Alpine, Amador, Calaveras, Contra Costa, El Dorado, Fresno, Madera, Mariposa, Merced, Sacramento, San Joaquin, Stanislaus, Tuolumne
December 1964-January 1965	Regionwide	Slow Rise,	Major flooding and substantial damages occurred along the Stanislaus River, Cosumnes River, Deer Creek, and Dry Creek.	Alpine, Amador, Calaveras, Contra Costa, El Dorado, Fresno, Madera, Mariposa, Merced, Sacramento, San Joaquin, Stanislaus, Tuolumne
December 1966-March 1967	Regionwide	Slow Rise	Continuous above-normal precipitation from December 1966 through March 1967 resulted in the flooding of 35,000 acres of the San Joaquin River Basin. USACE estimated about $1,300,000 in flood damages.	Alpine, Amador, Calaveras, Contra Costa, El Dorado, Fresno, Madera, Mariposa, Merced, Sacramento, San Joaquin, Stanislaus, Tuolumne
April-July 1967	Stanislaus River, San Joaquin River, Fresno River, Mokelumne River	Slow Rise, Engineered Structure Failure	Prolonged high flows in leveed channels led to extensive seepage damage, about 90 percent to agricultural lands, as well as a few commercial, residential, and other areas, including public campgrounds, a sewage disposal plant, a country club, settling ponds, roads and private levees. USACE estimated 44,340 acres flooded with damages of $4.8 million. Two private levees breached on the Fresno River, flooding 1,800 acres of croplands.	Calaveras, Madera, San Joaquin, Stanislaus, Tuolumne
December 1968-February 1969 "Winter '69 Storms"	Regionwide	Slow Rise	Severe rain caused floods that struck the northern part of the region, and both rain and snowmelt floods occurred in the southern part of the region. This was a State-declared disaster.	Alpine, Amador, Calaveras, Contra Costa, El Dorado, Fresno, Madera, Mariposa, Merced, Sacramento, San Joaquin, Stanislaus, Tuolumne
December 1969-March 1970	Sacramento River, Mokelumne River, Delta: Mildred Island	Slow Rise	The flood season was climaxed by near-record snowmelt floods. The flood brought inundation to approximately 550,000 acres, including portions of several small towns.	Contra Costa, El Dorado, Sacramento, Stanislaus, San Joaquin
January-February 1980	Regionwide, Delta: Little Mandeville Island, Holland and Webb Tracts, Lower and Upper Jones Tracts, Mokelumne River SW of Galt	Slow Rise, Structure Failure	High releases from New Melones Lake flooded industrial waste ponds in Ripon and inundated 1,500 acres of farmland. Mobile homes were flooded in the San Joaquin River floodplain south of Stockton. In the Delta, levees on Webb Tract, Holland Tract, and Little Mandeville Island breached, inundating about 9,900 acres of farmland. Levees breached in the Delta and flooded 17,354 acres on Lower Jones Tract, Upper Jones Tract, and an area between the Mokelumne River and Dry Creek southwest of Galt.	Alpine, Amador, Calaveras, Contra Costa, El Dorado, Fresno, Madera, Mariposa, Merced, Sacramento, San Joaquin, Stanislaus, Tuolumne

Table SJ-4. Selected Flood Events, San Joaquin River Hydrologic Region

Date	Location	Flood Type	Description	County
October 1982-March 1983	Regionwide, Delta: Fay Island, Mildred Island, Little Frank's Tract, Shima Tract, Mokelumne River southwest of Galt	Slow Rise, Stormwater, Engineered Structure Failure, Debris Flow	In January, Orestimba, Crow, Salado, and Del Puerto creeks overflowed and flooded small communities. A levee breached and flooded about 1,200 acres in an area between the Mokelumne River and Dry Creek southwest of Galt.	Alameda, Alpine, Amador, Calaveras, Contra Costa, El Dorado, Fresno, Madera, Mariposa, Merced, San Joaquin, Stanislaus, Tuolumne
January-March 1986 "St. Valentine's Day Storm"	Regionwide—Sutter Creek. Northern, Central California (including Bay Area), Delta: Little Mandeville Island, southwest of Galt	Slow Rise, Debris Flow, Structure Failure	Flash flooding damaged roads and some structures in scattered places. A levee on the Mokelumne River failed, inundating the town of Thornton and the 9,300-acre New Hope Tract. Rains, winds, flooding and mudslides were prevalent. Three major flood events in the Central Valley caused little damage in the San Joaquin River region, although urban and small-stream flooding was widespread.	Alpine, Amador, Calaveras, Contra Costa, El Dorado, Fresno, Madera, Mariposa, Merced, Sacramento, San Joaquin, Stanislaus, Tuolumne
January – April 1995	Regionwide	Slow Rise, Debris Flow, Flash, Stormwater	Urban stormwater and small-stream flooding were widespread. The Mokelumne River inundated Interstate 5 near Thornton and flooded agricultural lands.	Amador, Calaveras, Contra Costa, Fresno, Madera, Mariposa, Merced, Sacramento, San Joaquin, Stanislaus, Tuolumne
December 1996 - January 1997	Regionwide—Sutter Creek in cities of Ione, Sutter Creek Jackson Creek in Jackson, High elevations, valley region, Kings River, Fresno River, Bear Creek, Central Valley, San Joaquin Valley, Delta: Stewart Tract, Pescadero District, Mossdale; Carson River; Stanislaus River	Slow Rise, Engineered Structure Failure	Fourteen levee breaches occurred on the San Joaquin River between Fresno and the Chowchilla Bypass, inundating agricultural lands, including many vineyards north of the river.	Alpine, Amador, Calaveras, Contra Costa, El Dorado, Fresno, Madera, Mariposa, Merced, Sacramento, San Joaquin, Stanislaus, Tuolumne
June 2004	Delta: Lower Jones Tract	Structure Failure	The Lower Jones Tract levee failed, inundating the 5,894-acre island.	San Joaquin
December 2005-January 2006	Regionwide	Slow Rise, Debris Flow	Amador County sustained extensive damages to the public road system due to severe storms, flooding, mudslides, and landslides.	Alameda, Amador, Contra Costa, El Dorado, Fresno, Sacramento, San Joaquin
March – May 2006	Regionwide—Cities of Plymouth, Ione, Jackson; and Sacramento River, San Joaquin River, Kings River	Flash, Debris Flow, Engineered Structure Failure	Local flooding occurred, adjacent to several streams. Floods followed a month of above-average rainfall in California. Severe rainstorms, flooding, landslides, and mudslides were prevalent.	Alameda, Alpine, Amador, Calaveras, Contra Costa, El Dorado, Fresno, Madera, Merced, Sacramento, San Joaquin, Stanislaus, Tuolumne

3.7.3 History of Flood Response

In the San Joaquin River Hydrologic Region, the major types of flooding include slow rise, flash, and stormwater flooding. As a result of and in response to the regionally specific flood risks a number of traditional flood management projects have been developed. These include construction of a network of lakes and reservoirs for flood control, levees, bank protection, channel improvements, and diversion dams.

Mendota Flood Work, 1978

Flood Management Infrastructure

The San Joaquin River Hydrologic Region contains floodwater storage facilities and channel improvements that were partially funded and/or cosponsored by State and Federal agencies. Flood management agencies are responsible for operating and maintaining water management facilities, including more than 4,750 miles of levees, more than 260 dams and reservoirs, and other facilities in the hydrologic region; however, not all of these are dedicated for flood management or have flood storage

Constructed facilities in the San Joaquin River Hydrologic Region consist of the San Joaquin River Flood Protection (SJRFP) system and other flood protection works. The SJRFP system includes the following eight projects:

- Farmington Flood Control Basin on Littlejohns Creek,
- Canal Creek Flood Detention Reservoir on Canal Creek
- Bear Creek Flood Detention Reservoir on Bear Creek
- Burns Creek Flood Detention Reservoir on Burns Creek
- Owens Creek Flood Detention Reservoir on Owens Creek
- Mariposa Creek Flood Detention Reservoir on Mariposa Creek
- Smaller reservoirs on Mustang Creek, Deer Creek, Dry Creek, the North Fork Tuolumne River, and Bear Creek
- Bypasses, diversions, levees, channels, channel improvements, control structures, clearing and snagging, and bank protection on the San Joaquin River and many of its major tributaries

For a list of major infrastructure, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*. Also, flood infrastructure maps for each county are provided in *Attachment D: Summary of Exposure and Infrastructure Inventory by County (Mapbook)*.

Flood Management Governance

Although primary flood management responsibility might be assigned to a specific local entity in the San Joaquin River Hydrologic Region, aggregate responsibilities are spread among 208 agencies and cities with many different governance structures. Some of the larger agencies in the San Joaquin River Hydrologic Region include the following:

- Contra Costa Flood Control and Water Conservation District
- Fresno Irrigation District
- Madera County Flood Control and Water Conservation District
- Merced Irrigation District
- Sacramento County Department of Water Resources
- San Joaquin Area Flood Control Agency

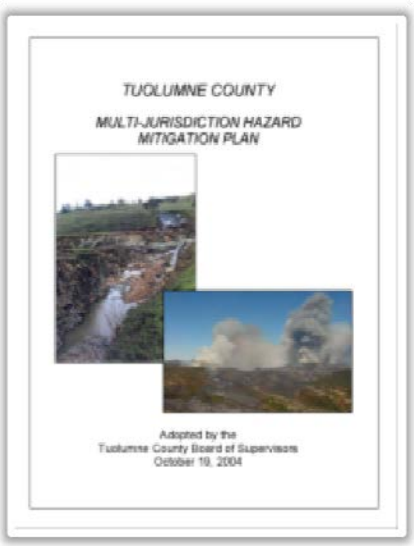
For a comprehensive list of agencies with flood management responsibilities, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

Flood-Related Regulations

Several agencies in the region have implemented regulations that directly impact flooding and flood management. For example, CVFPB has adopted designated floodways on the Cosumnes, Mokelumne, San Joaquin, Kings, Tuolumne, Merced, Chowchilla, and Fresno rivers; Dry Creek (tributary to the Tuolumne River near Modesto); Ash Slough; and Berenda Slough. This limits what can be constructed within the floodway for specific design storm events (e.g., 100-year event).

Flood Emergency Planning Efforts

Emergency management is a significant concern within the San Joaquin Hydrologic Region due to history of flooding in the region.



Tuolumne County Multi-Jurisdiction Hazard Mitigation Plan, 2004

Multi-Hazard Mitigation Plans. FEMA-approved MHMPs are on file for a number of counties in the San Joaquin River region. For a list of the entities in the San Joaquin River region that have adopted MHMPs, along with the corresponding dates of FEMA approval with corresponding dates of approval, refer to Appendix D. Other risk assessment studies were prepared by various entities, including USACE, FEMA, and the State Reclamation Board of California. For a comprehensive list of studies, refer to *Attachment G: Risk Information Inventory*.

Flood Insurance. FEMA has provided FIRMs for most areas within the region. FIRMs in 10 of the region's 16 counties were prepared after 2008, and three more were updated in 2010. One county had a partial update in 2008, and two are not scheduled for updates. In the San Joaquin River Hydrologic Region, the counties of Alpine, Contra Costa, Fresno, San Joaquin and Solano plus the cities of Lathrop, Manteca and Stockton, participate in the CRS program.

3.7.4 Current Flood Management

In the San Joaquin River Hydrologic Region, 59 local and USACE flood management projects or planned improvements were identified as part of the SFMP information gathering effort. Of these 59 projects, 51 projects have identified costs, approximately $780 million. Twenty-five projects were identified to use an IWM approach, with costs of approximately $130 million. An example of an IWM approach is the project for East Antioch Creek Marsh Restoration in Contra Costa County. This project is located in the lower reach of East Antioch Creek between the San Joaquin River and Lake Alhambra. The reservoir rehabilitation will enhance marsh expansion and restoration, increase tidal and storm flow capacity, and establish community-based conservation through public education and outreach programs. These projects and improvements are summarized in *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

Black Rascal Creek, 2006

In addition, DWR administers the IRWM Grant Program, which has supported development of IRWM plans in the region. Five of the eight IRWM plans in this region address flood control.

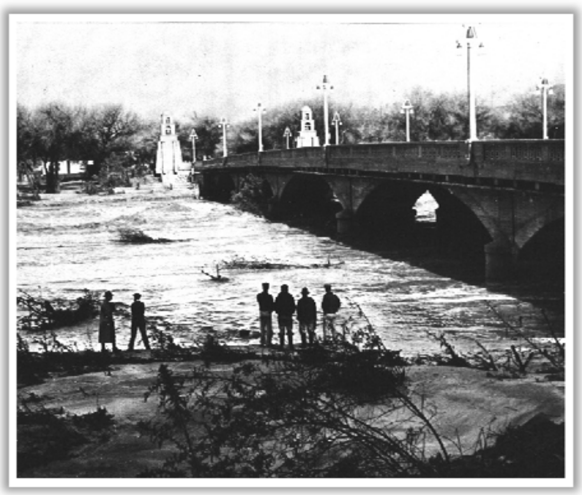
- *East Contra Costa County IRWM Plan*, adopted in 2006, emphasizes the relationship of flood control and ecosystem benefits, and identifies eight flood control projects (City of Antioch et al., 2006).
- *Cosumnes, American, Bear, Yuba Region IRWM Plan* of 2013 recommends projects that reduce flood damages to existing water resource infrastructure and notes the connection between flood control and ecosystem benefits (CABY, 2013).
- *Mokelumne/Amador/Calaveras IRWM Plan*, established in 2006, suggests 14 projects that have direct flood control benefits and use diverse flood control strategies, such as reservoirs, channel modifications, and wastewater treatment facility, drainage, and culvert improvements (RMC Water and Environment, 2006).
- *Westside Regional Drainage Plan*, adopted in 2003, has proposed constructing a flood detention reservoir on Panoche Creek within retired farmlands (San Joaquin River Exchange Contractors Water Authority et al., 2003).
- *Madera County IRWM Plan*, adopted in 2008, does not identify specific flood control projects to be implemented. Instead, the plan discusses a suite of strategies such as *Arundo donax* eradication for lessening flood risks (Madera County et al., 2008).

3.8 South Coast Hydrologic Region

3.8.1 Regional Setting

The South Coast Hydrologic Region extends from the Pacific Ocean east to the Transverse and Peninsular Mountain ranges, and from the Ventura-Santa Barbara County line south to the border with Mexico. The dominant topographic features are 225 miles of coastline with several prominent estuaries and many miles of beaches, wide coastal and interior plains, and rugged mountain ranges. River and creek systems within the South Coast Hydrologic Region nominally drain into the Pacific Ocean, although Lake Elsinore acts as a sink for the San Jacinto River system in all but the wettest of years. Five river systems account for the predominant portion of regional runoff—the Santa Clara, Los Angeles, San Gabriel, Santa Ana, and San Diego river systems.

Laguna Canyon Channel Flooding, 1969



Old Mission Bridge, 1938, Riverside County

The South Coast Hydrologic Region is highly urbanized, even as the headwaters of many streams have remained largely undeveloped. Flooding is exacerbated by long periods of intense precipitation, streams crossing over alluvial fans, and shoreline flooding in low-lying areas. Slow-rising streams and debris flows each account for about a third of the flooding. Stormwater floods are common. High-intensity storms often produce flash floods, particularly in the inland areas. The area has water-supply reservoirs of all sizes and many flood management facilities, some of which have sustained notable structural failures. Alluvial fan flooding is a recurring problem below the steep mountain canyons, and coastal damage occurs occasionally. Tsunamis, although theoretically possible, have caused little damage.

More than 3.4 million people and over $230 billion in assets are exposed to 500-year floodplains in the region. Three hundred forty-seven plant and animal species that are State- or Federally listed as threatened, endangered, or rare are exposed to flood hazards in the South Coast Hydrologic Region. Table SC-1 provides a snapshot of people, structures, crops, and infrastructure exposed to flooding in the region.

Table SC-1. South Coast Hydrologic Region Exposures within the 100-Year and 500-Year Floodplains

Segment Exposed	100-year (1%) Floodplain	500-year (0.2%) Floodplain
Population (total exposed, %)	393,100 (2%)	3,411,900 (19%)
Total Depreciated Replacement Value of Exposed Structures and Contents	$35.7 billion	$231.3 billion
Exposed Crop Value	$216 million	$424.8 million
Exposed Crops (acres)	46,200	1,215,500
Tribal Lands (acres)	583	586
Essential Facilities (count)	165	1,299
High Potential-Loss Facilities (count)	101	772
Lifeline Utilities (count)	21	87
Transportation Facilities (count)	803	2,074
Department of Defense Facilities (count)	16	16
Plant species State- or Federally listed as Threatened, Endangered, or Rare[a]	210	210
Animal species State- or Federally listed as Threatened, Endangered, or Rare[a]	136	137

Note:

[a]Many Sensitive Species have multiple occurrences throughout the state, and some have very large geographic footprints that may overlap more than one analysis region. As a result, a single Sensitive Species could be counted in more than one analysis region. Because of this, the reported statewide totals will be less than the sum of the individual region reports

Topographically, most of the South Coast Hydrologic Region consists of several large, undulating coastal and interior plains. The northern and eastern boundaries of the region consist of several prominent mountain ranges, including the San Gabriel and San Bernardino mountains. Nineteen rivers and watersheds are in the South Coast Hydrologic Region. Figure SC-1 illustrates the location of major features in the region, including streams and rivers. Many of the watersheds have densely urbanized lowlands with concrete-lined channels and dams controlling flood flows. The headwaters for many rivers, however, are within coastal mountain ranges and have remained largely undeveloped. Most of the rivers in the hydrologic region drain into the Pacific Ocean, and many terminate in lagoons or wetland areas. Flooding is marked by long periods of intense precipitation, streams crossing alluvial fans, shoreline flooding in low-lying areas, and potential tsunamis.

Stream Descriptions

Table SC-2 includes a detailed description of each watercourse in the South Coast Hydrologic Region. The descriptions proceed from north to south along the Pacific Coast, followed by the San Jacinto River system that ends in a sink at Lake Elsinore. Tributaries are listed in upstream order. Indentations, sub-letters, and numbers indicate tributary status.

South Coast Rivers

Figure SC-1 Rivers and Streams of the South Coast Hydrologic Region

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

Table SC-2. Stream Descriptions, South Coast Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM SYSTEMS ENTERING THE PACIFIC OCEAN OR A CONNECTED BAY					
1	Ventura River	Transverse Ranges N of Ojai	S		W of Ventura
1A	San Antonio Creek[c]	Transverse Ranges NE of Ojai	SW		N of Casitas Springs
1A1	Stewart Creek	Transverse Ranges N of Ojai	S		S of Ojai
1A2	Thacher Creek	Transverse Ranges NE of Ojai	SW		SE of Ojai
1A2a	Reeves Creek	Transverse Ranges E of Ojai	W		E Ojai Valley
1B	Matilija Creek	Crest of the Santa Ynez Mountains	SE		NW of Meiners Oaks
2	Santa Clara River	San Gabriel Mountains NE of Newhall	W, SW		S of Ventura
2A	Santa Paula Creek	Transverse Ranges N of Santa Paula	S		Santa Paula
2A1	Sisar Creek	Topatopa Bluff	S, E		Sulphur Springs
2B	Sespe Creek	S of Pine Mountain	E, S		Fillmore
2C	Piru Creek	E of Pine Mountain	E, S		S of Piru
2D	Castaic Creek	Liebre Mountain N of Castaic Lake	S		Newhall Ranch
2D1	Elizabeth Lake Canyon	Sawmill Mountain NE of Castaic Lake	SW		In Castaic Lake
3	Calleguas Creek (Arroyo Las Posas, Arroyo Simi)	Santa Susana Mountains NE of Simi Valley	W, S		Mugu Lagoon
3A	Revolon Slough	Between Oxnard and Camarillo	S		N of Mugu Lagoon
3A1	Beardsley Wash	South Mountain S of Santa Paula	S		Between Oxnard and Camarillo
3B	Las Llajas Creek	Santa Susana Mountains NE of Simi Valley	SW		Simi Valley
3C	Hummingbird Creek	Santa Susana Mountains NE of Corriganville	SW		Santa Susana Park
4	Malibu Creek	Simi Hills	S		Malibu Lagoon
5	Kenter Canyon Creek	Santa Monica Mountains	S		Santa Monica Pier
6	Ballona Creek	SE Santa Monica Mountains	S		S of Marina del Rey
7	Dominguez Channel	E of Los Angeles International Airport	S, SE		Los Angeles Harbor
8	Los Angeles River	W San Fernando Valley	E, S	Sepulveda FC Basin	Los Angeles Harbor
8A	Rio Hondo	San Gabriel Mountains N of Duarte	S	Whittier Narrows FC Basin	Near South Gate
8A1	Eaton Wash	W of Mount Wilson	S	Eaton Wash Reservoir	Rosemead
8A2	Santa Anita Wash	E of Mount Wilson	S	Santa Anita Reservoir	N of El Monte

Table SC-2. Stream Descriptions, South Coast Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM SYSTEMS ENTERING THE PACIFIC OCEAN OR A CONNECTED BAY					
8B	Arroyo Seco	W of San Gabriel Peak	S, SW	Devil's Gate Reservoir	N of Los Angeles Civic Center
8C	Big Tujunga Creek (Tujunga Wash)	Vetter Mountain	W, S	Big Tujunga Reservoir Hansen FC Basin	Studio City
8C1	Pacoima Diversion Channel	Pacoima Creek at Pacoima	SE		E of Panorama City
8C1a	Pacoima Creek (Pacoima Wash)	W of Mount Gleason	E, S	Pacoima Reservoir Lopez FC Basin	Pacoima Spreading Grounds
8D	Bell Creek	Simi Hills S of Simi Valley	SE	Sepulveda FC Basin	In Sepulveda FC Basin
9	San Gabriel River	Blue Ridge N of Mount San Antonio	W, SW, S	San Gabriel Reservoir Santa Fe FC Basin Whittier Narrows FC Basin	Seal Beach
9A	Coyote Creek	Puente Hills N of La Habra	SW		Rossmoor
9A1	Carbon Creek	Puente Hills W of Los Serranos	SW, W	Carbon Canyon Reservoir	W of Cypress
9A2	Fullerton Creek	NE of Olinda	SW, W		Cerritos
9A2a	East Fullerton Creek	Olinda	SW	Fullerton Reservoir	E of Fullerton
9A3	Brea Creek	S of Otterbein	SW	Brea Reservoir	Fullerton
9B	San Jose Creek	N Pomona	SW, NW		Industry
9B1	Thompson Creek	Potato Mountain N of Claremont	SW	Thompson Creek Reservoir	Pomona
9C	Walnut Creek	N of San Jose Hills	W	Puddingstone Reservoir	El Monte
9C1	Big Dalton Wash	San Gabriel Mountains N of San Dimas	SW	Big Dalton Reservoir	West Covina
9C1a	San Dimas Wash	Peacock Saddle	SW	San Dimas Reservoir Puddingstone Diversion Reservoir	Covina
9C2	Live Oak Creek	N of La Verne	SW	Live Oak Reservoir	In Puddingstone Reservoir
9C2a	Marshall Creek	N of La Verne	S		At Puddingstone Reservoir
9D	West Fork San Gabriel River	Red Box Gap	E	Cogswell Reservoir	In San Gabriel Reservoir

Table SC-2. Stream Descriptions, South Coast Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM SYSTEMS ENTERING THE PACIFIC OCEAN OR A CONNECTED BAY					
10	Santa Ana River	S of Lake Arrowhead and Big Bear Lake	W, SW	Seven Oaks Reservoir Prado Reservoir	N of Newport Beach
10A	Santiago Creek	Santiago Peak	NW, W	Villa Park Reservoir	Santa Ana
10B	Chino Creek	Puente Hills S of Pomona	SW		In Prado Flood Control Basin
10B1	Cucamonga Creek	Cucamonga Peak	SW		In Prado Flood Control Basin
10B1a	Day Creek	Cucamonga Peak	SE		SW of Chino[b]
10B1a1	Etiwanda Creek	San Gabriel Mountains SE of Cucamonga Peak	S		SW of Fontana[b]
10B1a1i	San Sevaine Creek	San Sevaine Flats	S		Near Etiwanda[b]
10B1a1i1	Fontana Creek	Below San Sevaine Flats	S		NW of Etiwanda
10B1a1ii	East Etiwanda Creek	San Sevaine Flats	S		N of Etiwanda
10B1b	Deer Creek	Cucamonga Peak	S		East of Ontario
10B2	San Antonio Creek[d]	Mount San Antonio	S	San Antonio Reservoir	Chino
10C	Temescal Creek[a] (Temescal Wash)	Lake Elsinore	NW		In Prado FC Basin
10C1	Oak Street Drain	Tin Mine/Hagador Canyons in the Santa Ana Mountains	N		N of Corona
10D	Tequesquite Arroyo	NW of March Field	N, NW		SW of Mount Rubidoux
10D1	Sycamore Canyon	W of Edgemont	NW	Sycamore Canyon Reservoir	Riverside
10E	Riverside Canal	SW of Fillmore Street in Arlington Heights	NE		N of Grand Terrace
10E1	Woodcrest Creek	Near Woodcrest	NE	Woodcrest Reservoir	Near Adams Street in Arlington Heights
10E2	Lake Mathews outlet canal	Lake Mathews	NW		Near Home gardens
10E2a	Cajalco Canyon	Santa Ana Mountains SW of El Cerrito	E		Lake Mathews
10F	Warm Creek	McKinley Mountain N of Highland	SW		N of Grand Terrace
10F1	Lytle Creek	NE of Mount San Antonio	SE		San Bernardino
10F1a	Cajon Creek	NE of Wrightwood	SE		NW of San Bernardino
10F1a1	Cable Creek	Sugarpine Mountain	S		W of Muscoy
10F1a1i	Devil Creek	S of Cedarpines Park	S		N of Muscoy

Table SC-2. Stream Descriptions, South Coast Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM SYSTEMS ENTERING THE PACIFIC OCEAN OR A CONNECTED BAY					
10F2	City Creek	S of Lake Arrowhead	S, W		San Bernardino
10F3	East Twin Creek	S of Crestline	S		San Bernardino
10F3a	Harrison Canyon	N of San Bernardino	S		San Bernardino
10G	San Timoteo Creek	W of Beaumont	NW		E of Colton
10G1	Yucaipa Creek	N of Cherry Valley	W		Ordway
10G1a	Wilson Creek	E of Allen Peak	SW		W of Calimesa
10G1a1	Oak Glen Creek	Cedar Mountain N of Oak Glen	SW		N of Yucaipa
10G2	Little San Gorgonio Creek	Cedar Mountain N of Cherry Valley	S		W of Beaumont
10G3	Noble Creek	Cedar Mountain N of Cherry Valley	S		W of Beaumont
10H	The Zanja	Crafton Hills	W		S of San Bernardino
10I	Gage Canal	Near McAllister Street in Arlington Heights	NE		N of Loma Linda
10I1	Box Springs Creek	Box Springs Mountains	W	Box Springs Reservoir	Riverside
10I2	Allesandro Creek	W of March Field	NW	Allesandro Reservoir	E of Prenda
10I3	Prenda Creek	N of Woodcrest	NW	Prenda Reservoir	S of Prenda
10I4	Mockingbird Canyon	Near Glen Valley	W, NW	Mockingbird Reservoir	Near Van Buren Boulevard in Arlington Heights
10I5	Harrison Creek	N of Lake Mathews	NW	Harrison Street Reservoir	Arlington Heights
10J	Mill Creek	S of San Gorgonio Mountain	W		N of Mentone
10J1	University Creek	Cedar Mountain SE of Mountain Home Village	NW		SE of Mountain Home Village
11	San Juan Creek	E slope of Santa Ana Mountains	SW		S of Dana Point
11A	Trabuco Creek	Santa Ana Mountains W of Lake Elsinore	W, SW, S		S of San Juan Capistrano
12	San Onofre Canyon	Santa Margarita Mountains in Camp Pendleton	W		San Onofre State Beach
13	Santa Margarita River	W of Gavilan Mountain	SW		N of Oceanside
13A	De Luz Creek	Santa Margarita Mountains NW of Fallbrook	S		W of Fallbrook
13B	Sandia Creek	SW of Murrieta	SW, S		N of Fallbrook
13C	Temecula Creek	N slope of Aguanga Mountain	NW, SW		N of Fallbrook
13C1	Murrieta Creek	SE of Lake Elsinore	SE		S of Temecula

Table SC-2. Stream Descriptions, South Coast Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM SYSTEMS ENTERING THE PACIFIC OCEAN OR A CONNECTED BAY					
14	San Luis Rey River	Combs Peak	SW, NW, SW		Oceanside
14A	Moosa Creek	E of Valley Center	NW		S of Bonsall
14B	Ostrich Farm Creek	Fallbrook	S		N of Bonsall
14C	Keys Creek	NE of Valley Center	W		S of Pala Mesa
15	Loma Alta Creek	W part of Vista	SW		Oceanside
16	Buena Vista Creek	San Marcos Mountains E of Vista	SW		Buena Vista Lagoon at Carlsbad
17	San Dieguito River	E of Escondido	SW		Del Mar
17A	Gonzales Canyon	Foothills of Black Mountain E of Del Mar	W		E of Del Mar
17B	Santa Ysabel Creek	W slope of Volcan Mountains	W		SE of Escondido
17B1	Guejito Creek	Rodriquez Mountain	S		San Pasqual
18	Soledad Canyon	Miramar	NW		Torrey Pines State Beach
18A	Carmel Valley (McGonigle Canyon)	Black Mountain	SW		Soledad Valley
18B	Los Peñasquitos Creek	NW of Poway	SW, NW		Soledad Valley
19	San Diego River	E of Santa Ysabel	S, SW		San Diego S of Mission Bay
19A	Forester Creek	La Cresta and El Cajon	W, NW		NW of Santee
19B	Los Coches Creek	SW of El Capitan Reservoir	W		Riverview Farms
19C	San Vicente Creek	S of Ramona	S		Moreno
19C1	Wildcat Canyon	S of Barona	S		Moreno
19C2	Slaughterhouse Canyon	NW of Eucalyptus Hills	SE		Below San Vicente Reservoir
20	Sweetwater River	E slope of Cuyamaca Mountains	SW		San Diego Bay
21	Paradise Creek	Chula Vista	W		San Diego Bay at Chula Vista
22	Telegraph Canyon	S slope of San Miguel Mountain	SW		San Diego Bay at Chula Vista
23	Otay River	Lyons Peak and other mountains E of the San Diego urban area	SW, W		San Diego Bay N of Imperial Beach
24	Tijuana River	Enters U.S. S of Little Tecate Peak, exits to Mexico, returns at San Ysidro	W		S of Imperial Beach

Table SC-2. Stream Descriptions, South Coast Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM SYSTEMS ENTERING THE PACIFIC OCEAN OR A CONNECTED BAY					
24A	Smugglers Gulch	Enters U.S. NW of Tijuana, Mexico	N		SE of Imperial Beach
24B	Cottonwood Creek	W slope of Laguna Mountains	S, W, SW		S of Little Tecate Peak
25	San Jacinto River	W slope of San Jacinto Mountains	NW, SW	Lake Elsinore Reservoir	Lake Elsinore
25A	Salt Creek	S of Menifee	N, W		In Railroad Canyon Reservoir
25B	Perris Valley Storm Drain	N of Lake Perris	S		E of Perris
25B1	Pigeon Pass Creek	Above Pigeon Pass Valley	SW, S	Poorman Reservoir	W of Lake Perris
25C	Bautista Creek	SW slope of Thomas Mountain	NW		SE of San Jacinto

Key:

E East, easterly, eastern
FC Flood Control
N North, northerly, northern
S South, southerly, southern
U.S. United States of America
W West, westerly, western

Notes:

[a] Lake Elsinore is nearly always a sink, but in extremely high water, it can overflow into Temescal Creek.

[b] Assumed high-water outlet.

[c] Ventura County

[d] San Bernardino County

Peak Flows

Table SC-3 provides peak flow information in the South Coast Hydrologic Region and shows a correlation between significant flood events and peak flows.

- The highest peak discharge in the South Coast region was observed in Santa Clara River in 1969.
- Four streams have had peak discharges of more than 50,000 cfs
- The most recent flood with recorded flows occurred in 2005.

Table SC-3. Record Flows for Selected Streams, South Coast Hydrologic Region

Stream	Location	Mean Annual Runoff (taf)	Peak Stage of Record (feet)	Peak Discharge of Record (cfs)	Date of Peak Discharge
Ventura River	Near Ventura	51[b]	29.3[a]	63,600	2/10/1978
Santa Clara River	At Montalvo[c]	122	17.4	165,000	1/25/1969
Santa Clara River	Near Piru	55	12.7[a]	32,000	1/10/2005
Sespe Creek	Near Fillmore	93	25.0[a,d]	85,300	1/10/2005
Piru Creek	Above Frenchman's Flat	31	N/A	36,000	2/25/1969
Calleguas Creek	Near Camarillo	37	10.5[a]	25,900	3/1/1983
Malibu Creek	At Malibu Canyon[f]	21	21.4	33,800	—
Ballona Creek	At Culver City[f]	36	16.0	32,500	—
Los Angeles River	At Sepulveda Dam	39	12.1[a]	14,700	3/4/1978
Rio Hondo	At South Gate[f]	38	15.4	48,100	—
Rio Hondo	Below Whittier Narrows Dam	125	13.8	38,800	1/25/1969
Big Tujunga Creek	Below Hansen Dam	182	7.6	15,200	2/10/1978
San Gabriel River	Below Santa Fe Dam, near Baldwin Park	47	22.2	30,900	1/26/1969
Santa Ana River	At Santa Ana	572	9.0	31,700	1/4/1995
Santa Ana River	At Municipal Water District crossing, near Arlington	1,152	16.6	47,800	1/11/2005
Temescal Creek	Above Main Street, at Corona	242	6.7	4,720	3/1/1983
Lytle Creek	At Colton	6	14.8	17,500	3/4/1978
San Timoteo Creek	Near Loma Linda	3	8.2	15,000	2/25/1969
San Juan Creek	At La Novia Street Bridge, at San Juan Capistrano	16	20.71	28,500	1/11/2005
Santa Margarita River	At Ysidora	452	20.5	44,000	1/16/1993
Santa Margarita River	Near Temecula	212	22.5	31,000	1/16/1993
Temecula Creek	Near Aguanga	6	14.6	8,100	1/16/1993
Murrieta Creek	At Temecula	152	17.2	25,000	1/16/1993
San Luis Rey River	At Oceanside	26	21.7	25,700	1/16/1993
Santa Ysabel Creek	Near Ramona	8	14.3	28,400	1/27/1916
San Diego River	At Fashion Valley, at San Diego	282	13.5	9,430	3/6/1995
San Diego River	At Mast Road, near Santee	18	18.1	45,400	2/16/1927
Cottonwood Creek	Above Tecate Creek, near Dulzura[e]	11	11.2	11,700	2/21/1980
San Jacinto River	Near Elsinore	12	11.8	16,000	2/17/1927
San Jacinto River	Near San Jacinto	14	5.31	45,000	2/16/1927
Salt Creek	At Murrieta Road, near Sun City	2	11.21	4,120	3/2/1983

Key:
cfs = cubic feet per second; taf = thousand acre-feet
Notes:
[a]Different date than peak discharge
[b]Most recent but less than period of record
[c]Gauge discontinued 2004
[d]Resulting from a debris wave
[e]Gauge discontinued 2007
[f]Data source not U.S. Geological Survey
The stations included in this table were selected from all USGS gauging stations in the hydrologic region, according to the following criteria:

- The watercourse must be a natural stream with a watershed of at least 100 square miles.
- The station must have a reasonably continuous record of discharge from 1996 to the present.
- The station must be far enough from other stations on the same river to reasonably represent a separate condition.
- Stations in well defined watercourse locations such as deep canyons are omitted, unless particularly important to the overall flood situation.

3.8.2 Historic Floods

Major floods occur regularly in the South Coast Hydrologic Region and take a variety of forms, with the major damage-producing events characterized by slow rise, alluvial fan, debris flow, coastal, flash, stormwater, engineered structure failure, and tsunamis. Flood damage has been observed in the South Coast Hydrologic Region since at least 1770. Reports from the California missions indicate significant South Coast regional flooding in the 72 years from 1770 to 1842. Table SC-4 presents an abridged synopsis of major floods in the region. For a more comprehensive list of flood events in the region, see Appendix B. Selected significant floods are briefly described below.

1861-62: The "Great Flood." As a result of the flooding in 1861-62, the mouth of the Los Angeles River shifted from Venice to Wilmington. The plains of Los Angeles County were extensively flooded and formed a large lake system where the stronger currents cut new channels to the sea. The Los Angeles, San Gabriel, and Santa Ana rivers converged, forming a solid expanse of water from Signal Hill to Huntington Beach. Runoff transformed much of what is now Orange County into an inland sea that was 4 feet deep in places 4 miles from the Santa Ana River.

February 1927. A flash flood on Santa Ana River, Los Angeles River, and San Jacinto River occurred, leading to channel improvements in San Bernardino, Riverside, Los Angeles, and Orange counties.

Perris Flood, 1927

March 1928. The St. Francis Dam, located 40 miles northwest of Los Angeles, catastrophically failed, and the resultant flood killed more than 600 people. The collapse of the St. Francis Dam caused the second greatest loss of life in California's history, exceeded only by the 1906 San Francisco earthquake and fire. The concrete dam was part of the Los Angeles Aqueduct system.

December 1937-March 1938. A flood inundating all Orange, Riverside, San Bernardino, Los Angeles, and Ventura counties caused an estimated $78.5 million in damages. High waves and high tides damaged three piers and coastal developments. In downtown Los Angeles, rainfall totaled 6.74 inches in 3 days. Eighty-eight people died, and an additional 127 bodies were never found. All buildings in Anaheim were damaged or destroyed. All rivers in Ventura County flooded. Highway 101 was washed out in the Oxnard area, and Oxnard and El Rio sustained considerable flooding. The bridge on State Route 118 was destroyed. The storm prompted demand for more flood control construction.

November-December 1965. In urban Los Angeles County, widespread flood damage was caused to improved channels, and local flooding was common. Floods along the Whitewater River washed out 22 county roads and 2,000 acres of agricultural lands were flooded with erosion or silting. State Highway 79 was closed for a few days to make repairs in the dip crossing and to remove debris. The Santa Ana River inundated farmland and drowned cattle and horses.


Orange County Flooding, 1969

January-February 1969. Flooding took the lives of 103 people and caused more than $160 million in damages to the South Coast Hydrologic Region. Due to increased development, the 1969 flood was the most damaging on record for parts of Ventura, Orange, San Bernardino, and Riverside counties. In Los Angeles County, the Los Angeles River, the San Gabriel River, and their tributaries damaged infrastructure and caused evacuation of thousands of people. Interstate 5 was closed at the Santa Clara River.

January-March 1978. In Orange County, the Santa Ana River and Santiago, Fullerton, and San Juan creeks flooded, damaging businesses, apartments, golf courses, and infrastructure. The San Diego River overflowed at Lakeside, which flooded 15 businesses and damaged infrastructure in Mission Valley, and deposited silt at San Diego Stadium. Debris deposition was widespread. Downtown Los Angeles rainfall totaled 5.21 inches between February 5 and February 10, and 8.35 inches between March 1 and March 6. Flooding from the Santa Ana River system damaged infrastructure in San Bernardino County. Damages caused by this event were estimated to be $86 million and took 20 lives.


Del Mar Racetrack, 1980

January-March 1980. A powerful series of storms destroyed homes, washed out bridges and roads, and disrupted utilities; 29 people lost their lives; road damage was widespread in the region, and high tides combined with the storms damaged coastal areas. In Ventura County, one of the heavy downpours during this event led to a spill at the Las Llajas Dam near Simi Valley and bridge damage in Moorpark. Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura counties were declared disaster areas by President Carter. Damages for the duration of the flood event reached $420,000,000. This event prompted concern that the flood control system was inadequate to handle a 100-year storm..

February-March 1983. Downtown Los Angeles rainfall totaled 5.26 inches, with six lives lost and $40 million in damages. The Santa Ana River crested its sides near the mouth of the ocean, creating a disaster for the low-lying areas of Huntington Beach where floodwaters were 3 to 5 feet deep. Approximately 1,400 people in Simi Valley were evacuated when the Sinoloa Dam was threatened with failure.

January-February 1993 San Diego County was hardest hit, especially along the Tijuana River, San Luis Rey River, Rainbow Creek, and Santa Margarita River. Fifteen people died as a result of this event in their attempt to cross the flooding Tijuana River. Approximately 1,000 people were isolated in the Fallbrook area for 5 days because all access roads were damaged. Los Angeles and Orange Counties suffered primarily landslide and erosional damage with localized inundation. Damage was scattered in San Bernardino and Riverside counties. .

January-March 1995. In January, local storm drains overflowed and damaged adjacent areas in many places. Flooding and mudslides closed State Highway 1 at several locations. Mud and water closed Amtrak's Saugus Tunnel. U.S. Highway 101 was inundated at the Ventura River. In March, numerous mudslides occurred throughout the coastal areas, destroying 12 homes in La Conchita. There also was widespread debris-flow and flood damage to homes, commercial buildings, and roads and highways in areas along the Malibu coast that had been devastated by wildfire 2 years before.

Alluvial Fan Flooding in Riverside County, 2004

October 2004. Heavy rains produced widespread flooding. Damage was estimated at $500,000 in Riverside County.

March 2011. A tsunami with maximum amplitude of 4.6 feet at Port Hueneme caused major damage to docks and boats at Ventura, Mission Bay, and Shelter Island in San Diego Bay. Docks and boats sustained less damage at Oxnard, Marina Del Rey, Redondo Beach, Santa Monica, Catalina Harbor, Los Angeles Harbor, Long Beach, Huntington Beach, and Dana Point. The West Coast and Alaska Tsunami Warning Center reported $150,000 in damages at Ventura.

Table SC-4. Selected Flood Events, South Coast Hydrologic Region

Date	Location	Flood Type	Description	County
1770, 1772, 1780, 1810, 1815, 1821, 1822, 1825, 1839, 1840, 1841, 1842	Los Angeles, Santa Ana, and San Diego Rivers	Slow Rise, Alluvial Fan	Mission sources note floods during this time.	Los Angeles, Orange, Riverside, San Bernardino, San Diego
December 1812	Ventura Coast	Tsunami	A tsunami damaged ships and inundated lowlands along the Ventura coast.	Ventura
December 1861-March 1862 "The Great Flood"	Arroyo Seco and Santa Ana River	Flash	The plains of Los Angeles County were extensively flooded and formed a large lake system where the stronger currents cut new channels to the ocean. The Los Angeles, San Gabriel, and Santa Ana rivers converged, forming a solid expanse of water from Signal Hill to Huntington Beach. Runoff transformed much of what is now Orange County into an inland sea that was 4 feet deep in places 4 miles from the Santa Ana River.	Los Angeles, Orange, Riverside, San Bernardino, San Diego, Ventura

Table SC-4. Selected Flood Events, South Coast Hydrologic Region

Date	Location	Flood Type	Description	County
February 1914	Los Angeles, Santa Ana, Ventura, Arroyo Seco, and San Gabriel rivers	Flash, Alluvial Fan, Debris Flow	Floodwaters caused more than $10 million in damages and took the lives of many people.	Los Angeles, Orange, Riverside, San Bernardino, Ventura
January 1916	Arroyo Seco; Los Angeles, Santa Ana, and San Gabriel Rivers; Lower Otay and Sweetwater Dams; San Diego and Tijuana rivers	Flash, Structure Failure, Debris Flow, Alluvial Fan	Flooding occurred along Arroyo Seco. The Los Angeles area sustained significant damage when inadequately sized bridges acted as debris plugs. The Lower Otay Dam failed in that flood, causing significant damage to developed areas in San Diego County. Two deaths and $4.5 million in damages occurred in San Diego County.	Los Angeles, Orange, Riverside, San Bernardino, San Diego, Ventura
1925	Los Angeles and Santa Ana Rivers	Flash, Alluvial Fan	A severe flood event occurred that altered the course of both the Santa Ana River and the Los Angeles River.	All Counties
February 1927	Santa Ana River San Jacinto River, Whitewater River, San Diego River	Flash	Heavy rain-caused damage to roads, bridges, rail lines, and agricultural lands was the result of this flooding event. There was heavy runoff due to soil saturation from earlier storms. Damages were estimated at $1,664,000 for Los Angeles, Riverside and San Diego counties.	Los Angeles, Orange, Riverside, San Diego, San Bernardino
March 1928	Santa Clara River, St. Francis Dam	Engineered Structure Failure	Located 40 miles northwest of Los Angeles, the dam catastrophically failed, and the resultant flood killed more than 600 people and caused $20 million in damages.	Los Angeles
December 1937-March 1938	Santa Ana River, City of Riverside, Whitewater River, Palm Springs, San Bernardino and San Gabriel Mountains, Santa Ana, San Gabriel, and Los Angeles Rivers, Deep Creek - Hesperia, West Fork Mojave River	Flash	A flood that inundated all of Orange, Riverside, San Bernardino, Los Angeles, and Ventura counties caused an estimated $78.5 million in damages. High waves and high tides damaged three piers and coastal developments, leaving 88 dead and 127 bodies that were never found.	Orange, Riverside, San Bernardino, San Diego, Ventura
February – March 1941	Los Angeles River	Flash, Slow Rise	Los Angeles River overflowed and caused floods, extending to Glendale. Downtown Los Angeles total rainfall for the February storm totaled 4.67 inches in 4 days. The 1940-41 season total of 32.79 inches was exceeded (at the time) only by totals of 1883-84 and 1889-90 seasons.	Los Angeles
February 1944	Los Angeles River, Santa Clara River	Flash	Rainfall in downtown Los Angeles totaled 7.19 inches. The storm produced unusual snow depths in the mountains (105 inches at Cedar Springs). Los Angeles River overflowed and caused floods. High flows in Santa Clara River were caused by rain and snowmelt runoff.	Los Angeles, Ventura
April 1946	Santa Catalina Island, Port Hueneme	Tsunami	This event inundated more than 250,000 acres in six counties, caused an estimated $79 million in damage, and killed 87 people.	Los Angeles, Ventura
July 1958	San Bernardino	Alluvial Fan, Flash	Intense storms in the area caused flash flooding.	San Bernardino

Table SC-4. Selected Flood Events, South Coast Hydrologic Region

Date	Location	Flood Type	Description	County
May 1960	Regional Coast	Tsunami	A tsunami was observed at stations along the entire West Coast, including 13 places in the South Coast region. One person died at Cabrillo Beach, and major damage was done to small craft. In San Diego, docks were destroyed near Point Loma, and boats and docks were damaged throughout the harbor. NOAA reported regional damage at $1 million.	Ventura, Los Angeles, Orange, San Diego
December 1963	Baldwin Hills	Engineered Structure Failure	The Baldwin Hills Dam failed, flooding downstream residences. Five people died, 24 homes were destroyed, and 2,000 homes and 3,000 automobiles were damaged. The flood covered half of a square mile. Damages were estimated at $15 million.	Los Angeles
November-December 1965	Regionwide	Alluvial Fan Debris Flow, Flash	In urban Los Angeles County, widespread floods damaged improved channels, and local flooding was common.	All Counties
December 1966-January 1967	Santa Ana River - Redlands, Mission-Anaja Creek, Day Creek, Lytle Creek, Cucamonga Creek, San Antonio Creek, Etiwanda Creek, Santa Clara River	Alluvial Fan, Slow Rise, Debris Flow, Stormwater, Flash	There was widespread damage to dams, stream channels, levees, highways, and bridges. Redlands, San Bernardino, and Indio sustained water and sewer infrastructure damage. Streets and homes were flooded throughout San Diego County, Otay, Bonita, Chula Vista, Hillcrest, Nestor, and Imperial Beach. Damages due to this event exceeded $3.5 million dollars to San Bernardino County infrastructure, including roads, bridges, flood control works and drainage facilities.	Los Angeles, Riverside, San Bernardino, San Diego Ventura,
January-February 1969	Regionwide	Flash, Debris Flow, Stormwater	Flooding took the lives of 103 people and caused more than $160 million in damages to the South Coast Hydrologic Region. Due to increased development, the 1969 flood was the most damaging on record for parts of Ventura, Orange, San Bernardino, and Riverside counties.	All Counties
January-March 1978	Countywide, most severe in south and east portions of county, Santa Clara River	Slow Rise, Debris Flow, Stormwater	In Orange County, the Santa Ana River and Santiago, Fullerton, and San Juan creeks flooded, damaging businesses, apartments, golf courses, and infrastructure.	All Counties
1979	La Mesa, Lemon Grove, National City, San Macros, San Diego	Alluvial Fan	Flooding in the cities of La Mesa, Lemon Grove, National City, San Marcos, and San Diego caused considerable damage. This was a high-intensity, short-duration flooding event. Damages due to this flood exceeded $2.5 million.	San Diego
January-March 1980	San Jacinto River, Western Riverside County, San Diego River, Santa Clara River, Small Canyon	Alluvial Fan, Stormwater, Flash	In 1980, a powerful series of storms left the region with destroyed homes, washed out bridges and roads, and disrupted utilities. Mud, erosion, and high water were experienced in all parts of San Diego County. Thousands of people were evacuated from the area, and 29 people lost their lives.	Los Angeles, Orange, Riverside, San Bernardino, San Diego, Ventura
February-March 1983	Countywide, Santa Clara River	Flash	Downtown Los Angeles rainfall totaled 5.26 inches, with six lives lost and $40 million in damages. Approximately 1,400 people in Simi Valley were evacuated when the Sinoloa Dam was threatened with failure. This flooding event coincided with extremely high tides, compounding damages in coastal areas.	Los Angeles, San Diego, Ventura

Table SC-4. Selected Flood Events, South Coast Hydrologic Region

Date	Location	Flood Type	Description	County
August 1983	Desert Areas	Alluvial Fan, Flash, Stormwater	Tropical Storm Ishmael brought high intensity periods of rain to Riverside County, especially in the desert regions near Cathedral City and Rancho Mirage. This event caused almost $19 million in damages.	Los Angeles, Riverside
January – February 1993 Great Flood of 1993	Regionwide	Slow Rise, Flash, Debris Flow, Stormwater	Severe rainfall created regionwide flooding that caused $14 million in damages in Los Angeles County. Landslides destroyed many houses throughout Southern California, and thousands of people were evacuated.	Los Angeles, Orange, San Bernardino, San Diego
January-March 1995	Regionwide	Slow Rise, Flash, Debris Flow, Alluvial Fan, Stormwater	Intense rainfall overflowed storm drains and caused widespread flooding. Flooding and mudslides closed State Highway 1 at several locations.	All Counties
January 1997	Ventura and Santa Clara Rivers, San Antonio Creek, Santa Ana River	Flash, Slow Rise	The Ventura River overflowed and damaged adjacent agricultural lands. San Antonio Creek and the Santa Clara River flooded and damaged nearby areas. Santa Ana River caused significant flooding also.	Los Angeles, Santa Barbara, Orange, Ventura
December 2003	Waterman Canyon, Devore, Little Creek, Manzanita Flats, City Creek	Alluvial Fan, Flash, Debris Flow	Sixteen deaths were recorded as a result of the debris flow flooding at Camp Sofia and Cable Canyon.	San Bernardino
October 2004	Perris, Mira Loma, Moreno Valley, Perris, Sun City, Lake Elsinore, San Jacinto River	Alluvial Fan, Debris Flow, Flash	Heavy rainstorms produced widespread flooding causing over $500,000 in damages in Riverside county alone. One person was killed near Lytle Creek.	Riverside, San Bernardino, San Diego
December 2004-January 2005	Regionwide	Debris Flow, Slow Rise, Flash, Alluvial Fan	Five days of heavy rains caused widespread flooding throughout Southern California and damages of $100 million. Twelve people died as a result of this event. Mudflows damaged a mobile home park in Newhall. Impacts were exacerbated by the 2004 fire. Homes in La Canada-Flintridge, Montrose, Castaic, and Val Verde were damaged by runoff and/or mudslides from burned hillsides.	Los Angeles, Orange, Riverside, San Bernardino, San Diego, Ventura
February 2010	Coastal Areas	Tsunami	A tsunami of 3.9 feet at Shelter Island in San Diego Bay damaged 20 docks and moved buoys at Ventura. The tsunami damaged docks and marine infrastructure at Oxnard, Marina Del Rey, Catalina, Los Angeles Harbor, Oceanside, and Shelter Island. It moved buoys at Mission Bay, and damaged boats and boat equipment at Dana Point, Oceanside, Mission Bay, and Shelter Island.	Los Angeles, Orange, San Diego, Ventura
March 2011	Coastal Areas	Tsunami	A tsunami with maximum amplitude of 4.6 feet at Port Hueneme caused major damage to docks and boats at Ventura, Mission Bay, and Shelter Island in San Diego Bay. Lesser damage was sustained by docks and boats at Oxnard, Marina Del Rey, Redondo Beach, Santa Monica, Catalina Harbor, Los Angeles Harbor, Long Beach, Huntington Beach, and Dana Point. The West Coast and Alaska Tsunami Warning Center reported $150,000 in damages at Ventura.	Los Angeles, Orange, San Diego, Ventura

3.8.3 History of Flood Response

In the South Coast Hydrologic Region, the major types of flooding include coastal, slow rise, flash, and debris flow flooding. In response to the regionally specific flood risks, a number of traditional flood management projects have been developed. These include construction of many reservoirs, channels, levees, detention basins, and debris basins.

Flood Management Infrastructure

The South Coast Hydrologic Region includes two of the most extensive flood control systems in California—the Los Angeles County Drainage Area (LACDA) Project, and the Santa Ana River Orange County (SAROC) system, which includes the Santa Ana River Project and the Santa Ana Main Stem Project. The region has 34 flood control reservoirs, including 5 on the LACDA system and 7 on the SAROC system, many debris basins, several detention basins, levees, channel improvements, and bypasses.

San Sevaine Channel at Union Pacific Railroad, Fontana, CA, shows railroad completely undermined

The LACDA Project is principally in the watersheds of the Los Angeles and San Gabriel rivers and the Rio Hondo. The project has one small flood control basin on Pacoima Wash and four major flood control reservoirs—Sepulveda Flood Control Basin on the Los Angeles River, Whittier Narrows Flood Control Basin on the San Gabriel River and Rio Hondo, Hansen Flood Control Basin on Tujunga Wash, and Santa Fe Flood Control Basin on the San Gabriel River. The LACDA Project also includes 90 debris basins on tributaries to the principal rivers and 458 miles of improved channels in the Los Angeles metropolitan area and the San Fernando Valley.

The SAROC system is on the Santa Ana River and its tributaries. Its six major flood control reservoirs include Carbon Canyon Reservoir on Carbon Creek, Prado and Seven Oaks Reservoirs on the Santa Ana River, Brea Reservoir on Brea Creek, San Antonio Reservoir on San Antonio Creek, and Villa Park Reservoir on Santiago Creek. The system also has one smaller reservoir on East Fullerton Creek, debris basins, detention basins, levees, bypasses, and improved channels.

Other facilities include:

- Debris basins on Beardsley Wash, Stewart Creek, and tributaries of the Santa Ana River
- Detention basin on Santiago Creek
- Diversion conduit on Kenter Canyon Creek
- Levees on the Ventura, Santa Clara, San Luis Rey, San Diego and Tijuana rivers and many of their tributaries

- Improved channels on Stewart Creek, Beardsley Wash, Kenter Canyon Creek, and on the Santa Clara, San Diego, Sweetwater, and Tijuana rivers and their tributaries

Detailed information regarding floods of record is tabulated in Appendix B of this attachment. Flood infrastructure maps for each county are provided in *Attachment D: Summary of Exposure and Infrastructure by County (Mapbook)*.

Flood Management Governance

Although primary responsibility for flood management might be assigned to a specific local entity in the South Coast Hydrologic Region, aggregate responsibilities are spread among more than 265 agencies with many different governance structures. Some of the larger agencies in the South Coast Hydrologic Region include the following:

- Los Angeles County Department of Public Works
- Los Angeles Flood Control District
- City of Los Angeles
- Orange County Public Works
- Riverside County Flood Control and Water Conservation District
- San Bernardino County Department of Public Works
- City of San Diego Storm Water Division
- Ventura County Public Works
- San Diego County Flood Control District

Agency roles and responsibilities can be limited by how the agency was formed, which might include enabling legislation, a charter, a memorandum of understanding with other agencies, or ownership. A comprehensive list of agencies with flood management responsibilities can be found in *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

Major flooding along the Los Angeles River in the 1800s and early 1900s

Flood-Related Regulations

Several agencies within the region have implemented regulations that directly impact flooding and flood management. For example, land development within the floodplains of the South Coast region is primarily regulated by local building codes, subdivision regulations, floodplain ordinances, coastal permits, and zoning ordinances. All counties and many cities have adopted such measures to protect their communities from flood hazards. Local land use jurisdictions have adopted floodplain management ordinances, identifying 100-year floodplains and floodways to qualify for participation in FEMA's NFIP.

Flood Emergency Planning Efforts

Emergency management is important because these programs can be used to inform the public, policymakers, and local agencies how to respond to a flood event and can help save lives when a flood event occurs. The Los Angeles Department of Public Works, Orange County Flood Control, and San Diego County have emergency management procedures that are put into place during storms.

Cole Grade Road, San Dieguito River

Multi-Hazard Mitigation Plans. FEMA-approved MHMPs were identified or collected for Orange, Los Angeles, Riverside, San Bernardino, San Diego, and Ventura counties. For a complete list of entities in the South Coast region that have adopted MHMPs with the corresponding dates of FEMA approval, see Appendix D. Other risk assessment studies were prepared by various entities, including USACE, FEMA, and the State Reclamation Board of California. For a comprehensive list of risk assessment studies, refer to *Attachment G: Risk Information Inventory*.

Flood Insurance. FEMA has provided FIRMs for all areas within the region. Five counties and 19 cities participate in the CRS program. For a comprehensive list of participating cities and counties, see Table C-4, California Communities CRS Participation and Savings.

3.8.4 Current Flood Management

In the South Coast Hydrologic Region, 355 local and USACE flood management projects or planned improvements were identified, with costs totaling about $8.4 billion; 97 percent of projects in the region have associated costs. Seventy-seven of these projects use an IWM approach to flood management, with those projects having identified costs of approximately $2.66 billion. An example of a project utilizing an IWM approach in this region is the North Atwater Creek Restoration Project, which will construct facilities for improvements to water quality in an area along the Los Angeles River. The project will restore the creek at the North Atwater Park for storm water runoff capture and treatment and will provide wetlands habitat linkage to the Los Angeles River. Two acres of wetland habitat will be created.

DWR administers the IRWM Grant Program, which supports development of IRWM plans in the region. The South Coast Hydrologic Region has a high density of IRWM plans covering the region. Of 14 plans, 5 have incorporated flood control and/or floodplain management components. Plans that include flood management components include the following:

- San Diego IRWM Plan, 2007, discusses the integration of floodplain management into the plan but does not elaborate on specific projects (Regional Advisory Committee, 2007).

- Central Orange County IRWM Plan, 2007, discusses the Orange County Flood Control District and the role it serves as a participating flood control entity in the plan (County of Orange, 2007).
- IRWM Plan of the Watersheds Coalition of Ventura County, established in 2006, is coordinated with the Integrated Watershed Protection Program, allowing for countywide planning of flood reduction measures over a 20-year horizon (Watersheds Coalition of Ventura County, 2006).
- San Jacinto River Watershed Management Plan, 2007, discusses a strategy that incorporates multi-objective projects for stormwater and flood management (San Jacinto River Watershed Council, 2007).
- Rancho California Water District/Upper Santa Margarita IRWM Plan, 2007, discusses floodplain management and the important role it plays in protecting public and private property (Rancho California Water District et al., 2007).

For example, in the Calleguas Creek basin, which is a 341-square-mile watershed, one of the ongoing projects is the Calleguas Creek Integrated Watershed Protection Plan Phase II Management Strategy Study. This project will provide multipurpose outcomes, including flood control, sedimentation balance and control, water quality improvement, land use management, groundwater recharge, ecosystem mitigation and restoration, and recreational opportunities. When and where opportunities become available, projects of this type will be proposed, planned, and implemented on a collaborative basis in all four zones within Ventura County.

Calleguas Creek, 2007

3.9 South Lahontan Hydrologic Region

3.9.1 Regional Setting

The South Lahontan Hydrologic Region includes Inyo County and portions of Mono, San Bernardino, Kern, and Los Angeles counties. It is bounded to the north by the drainage divide between Mono Lake and East Walker; to the west and south by the Sierra Nevada, San Gabriel, San Bernardino, and Tehachapi mountains; and to the east by the state of Nevada. Drainage for most of the watershed in the region remains in the region and often flows into dry lakebeds and playas. Dry lakebeds and playas are a result of waters from sudden storms that dry up due to the arid climate in the region. Most of the perennial rivers (such as Owens River and Rush Creek) in this region are in its northern portion and have runoff from the Sierra Nevada Mountain Range. In the south, the Mojave and Amargosa rivers typically are dry for most of the year, but water flows in the channels of both rivers after heavy rainfall. In addition, there are two locations on the Mojave River where groundwater is forced to the surface of the channel by geologic conditions.

More than 153,000 people and nearly $12 billion in assets are exposed to a 500-year flood event in the South Lahontan Hydrologic Region. Two hundred seventeen plant and animal species that are State- or Federally listed as threatened, endangered, or rare are exposed to flood hazards distributed throughout the region. Table SL-1 provides a snapshot of people, structures, crops, and infrastructure, exposed to flooding in the region.

50th Street, Los Angeles County, after a Flash Flood, 2005

Table SL-1. South Lahontan Hydrologic Region Exposures within the 100-Year and 500-Year Floodplains

Segment Exposed	100-year (1%) Floodplain	500-year (0.2%) Floodplain
Population (% total exposed)	19,900 (3%)	153,200 (21%)
Total Depreciated Replacement Value of Exposed Structures and Contents	$1.7 billion	$12 billion
Exposed Crop Value	$25.6 million	$59.5 million
Exposed Crops (acres)	41,400	72,200
Tribal Lands (acres)	3	10
Essential Facilities (count)	16	77
High Potential-Loss Facilities (count)	9	10
Lifeline Utilities (count)	4	8
Transportation Facilities (count)	60	94
Department of Defense Facilities (count)	4	4
Plant species State- or Federally listed as Threatened, Endangered, or Rare[a]	100	104
Animal species State- or Federally listed as Threatened, Endangered, or Rare[a]	113	113

Note:

[a]Many Sensitive Species have multiple occurrences throughout the state, and some have very large geographic footprints that may overlap more than one analysis region. As a result, a single Sensitive Species could be counted in more than one analysis region. Because of this, the reported statewide totals will be less than the sum of the individual regions.

The region is arid except at the higher elevations. The only perennial streams are the Owens River and some of its tributaries, which provide significant water supply for the Southern California urban areas. Some higher elevation streams, notably Deep Creek, are nearly perennial. The Mojave and Amargosa rivers are typically dry for most of the year. The infrequent storms are often intense, watercourses are steep and erosive, and vegetation is sparse. As a result, flash floods are the most prevalent type of flood, and these are often accompanied by debris flows. Slow rise floods also occur regularly. Winter storms generally produce the most damage, but thunderstorms often produce significant flooding in the summer. Desert areas are primarily flat and susceptible to shallow stormwater flooding. One structure failure has been recorded. Figure SL-1 illustrates the location of major features in the region, including streams and rivers.

Big Rock Wash Palmdale, 2005

Stream Descriptions

Table SL-2 provides a detailed description of each watercourse mentioned in connection with the South Lahontan Hydrologic Region. The descriptions proceed from north to south, based on location of the river system's sink. Tributaries are listed proceeding upstream. Indentation, sub-letters, and numbers indicate tributary status.

South Lahontan Rivers

Figure SL-1 Rivers and Streams of the South Lahontan Hydrologic Region

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

Table SL-2. Stream Descriptions, South Lahontan Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAM TRIBUTARY TO MONO LAKE					
1	Rush Creek	Ansel Adams Wilderness	E, NE		E of Lee Vining
STREAM SYSTEM TRIBUTARY TO OWENS LAKE					
2	Owens River	Sierra Nevada and White Mountains crests	SE		SE of Lone Pine
2A	Big Pine Creek	Sierra Nevada crest E and W of Mount Alice	W, NW		E of Big Pine
2B	Bishop Creek	Sierra Nevada crest NE of Kings Canyon National Park	NE		Near Bishop
2B1	Middle Fork Bishop Creek	Sierra Nevada crest at Mount Powell	NE		North of Aspendell
2B1a	North Fork Bishop Creek	Sierra Nevada crest S of Mount Emerson	E		Downstream of Lake Sabrina
STREAM TRIBUTARY TO BADWATER BASIN					
3	Amargosa River	E of Beatty, Nevada	S, SE, NW		SW of Badwater
STREAM SYSTEM TRIBUTARY TO SODA LAKE					
4	Mojave River	Near Lake Arrowhead	N, NE, E		Near Baker
4A	Oro Grande Wash	Near Cajon Summit	NE		Victorville
4B	Deep Creek	Near Lake Arrowhead and Big Bear Lake	N, NW		Mojave River Forks Reservoir
4C	West Fork Mojave River	NW slope of Sugarpine Mountain	NE	Mojave River Forks Reservoir	In Mojave River Forks Reservoir
STREAM SYSTEM TRIBUTARY TO ROSAMOND LAKE					
5	Big Rock Creek	W of Wrightwood	NW		N of Lancaster
5A	Little Rock Creek	Mount Waterman	N		NE of Lancaster
5A1	Anaverde Creek	Mount McDill W of Palmdale	E, NE		NE of Palmdale
STREAM SYSTEM TRIBUTARY TO EL MIRAGE LAKE					
6	Sheep Creek	Wright Mountain S of Wrightwood	N		NW of Victorville
6A	Swarthout Creek	SW slope of Table Mountain W of Wrightwood	E		Wrightwood

Key:

E East, easterly, eastern
S South, southerly, southern
N North, northerly, northern
W West, westerly, western

Peak Flows

Table SL-3 provides peak flow information in the South Lahontan Hydrologic Region and shows a correlation between significant flood events and peak flows.

- The most recent highest peak discharge was recorded in 2007 on Amargosa River.
- The highest recorded peak discharge was on Deep Creek in 1938.

Table SL-3. Record Flows, South Lahontan Hydrologic Region

Stream	Location	Mean Annual Runoff (taf)	Peak Stage of Record (feet)	Peak Discharge of Record (cfs)	Date of Peak Discharge
Bishop Creek	Above Power Plant No. 6, near Bishop	15	3.8	453	7/23/1998
Amargosa River	At Tecopa	3	16.0	10,600	8/19/1983
Amargosa River	At Highway 127, near the California-Nevada state line	N\A	20.6	660	9/22/2007
Mojave River	At Afton	6[b]	10.4	18,000	1/26/1969
Mojave River	At Barstow	15[b]	4.8	20,500	1/11/2005
Mojave River	At Lower Narrows, near Victorville	50	16.7	24,000	1/24/1998
Deep Creek	Near Hesperia	53	33.3[a,c]	46,600	3/2/1938
West Fork Mojave River	Near Hesperia[e,f]	29	10.8[a]	26,100	3/2/1938
Big Rock Creek	Near Valyermo[e]	13	7.7[a]	8,300	3/2/1938
Little Rock Creek	Above Little Rock Reservoir near Littlerock[e,g]	13	16.2[a]	17,000[d]	3/2/1938

Key:
cfs = cubic feet per second
taf = thousand acre-fee

Notes:
[a]Different date than discharge
[b]Most recent but less than period of record
[c]Backwater from downstream reservoir
[d]Outside period of record
[e]Regionally significant site with less than 100 square miles tributary watershed area
[f]Gauge discontinued 1971
[g]Gauge discontinued 2005

The stations included in this table were selected from all USGS gauging stations in the hydrologic region, according to the following criteria:

- The watercourse must be a natural stream with a watershed of at least 100 square miles.
- The station must have a reasonably continuous record of discharge from 1996 to the present.
- The station must be far enough from other stations on the same river to reasonably represent a separate condition.
- Stations in well defined watercourse locations such as deep canyons are omitted, unless particularly important to the overall flood situation.

3.9.2 Historic Floods

Major floods occur less regularly in the South Lahontan Hydrologic Region than in many other parts of the state. Flash floods, often accompanied by debris flows, typically are the most common, although larger streams may exhibit slow rise floods, and stormwater floods and structure failures could also occur. Records on most streams of the South Lahontan region began around 1930. Flood damage has been observed in the South Lahontan Hydrologic Region since at least 1938. Table SL-4 presents an abridged synopsis of historic floods in the region. For a more comprehensive list of flood events in the region, see Appendix B. Selected significant floods are briefly described below.

1861-62: The "Great Flood." The "Great Flood" of December 1861-January 1862 impacted the South Lahontan region along with the rest of the area. In the Owens Valley area, snow and flooding depleted the forage, reducing the game population important to local tribes.

February-March 1938. Widespread flooding caused damages estimated at $2.5 million. Twenty-two homes were destroyed by the Mojave River near Victorville.

August 1959. Extensive flood damage was caused to highways in Needles and homes in Joshua Tree.

January and February 1969. This was a series of storms that brought extremely heavy precipitation that first saturated the soil and then produced high levels of runoff. Although flood management facilities functioned during the January flood period, there was insufficient time to perform necessary repairs and maintenance before the late February storm struck, which caused nearly twice as much damage. Total losses from both the January and February storms in San Bernardino County amounted to more than $54 million. Widespread flooding occurred in the Mojave River lowlands, and nearly 3,000 homes were evacuated. All bridges and crossings between Victorville and Barstow were impassable.

August 1983. A flash flood inundated 20 vehicles in Barstow, and flash floods occurred in eastern Kern County. Flooding closed State Highway 247.

Debris Flow, Inyo County 2008

December 2004-January 2005. A very wet winter caused the Mojave River to flood resulting in severe damages in the region. Continued flooding impacted desert communities and resulted in FEMA Federal Disaster Declarations..

June-August 2008. A strong thunderstorm over the eastern slopes of the Sierra Nevada resulted in debris flows that damaged public and private property near Independence. Several structures were damaged at the Mt. Whitney Fish Hatchery, several homes below the hatchery, a campground, Highway 395, and property on a tribal reservation.

Table SL-4. Selected Flood Events, South Lahontan Hydrologic Region

Date	Location	Flood Type	Description	County
December 1861-January 1862	Regionwide	Flash, Slow Rise	Winter storms brought extremely high or record-breaking stages on streams, including the Walker River. Owens Valley experienced rainfall that resulted in the Owen River swelling to be up to 0.5 mile wide and Owens Lake rising 12 feet. People were killed on Bodie Creek.	Inyo, Kern, Los Angeles, Mono, San Bernardino
February-March 1938	Mojave River Basin, Lancaster, Palmdale, San Bernardino and San Gabriel Mountains, Santa Ana, San Gabriel, and Los Angeles Rivers, Deep Creek - Hesperia, West Fork Mojave River, Tehachapi Creek	Alluvial Fan, Debris Flow, Flash	Widespread damage occurred, approximately 80 percent in urban areas and the remainder in agricultural areas. Damage was estimated at $2.5 million. Two and half miles of track in Cajon Pass were washed out. All rail transportation was halted, approximately 30 daily trains. Mail service was halted. All utility infrastructures were lost, including electric lines, natural gas lines, domestic water supply lines, telephone lines, sewage lines and plants. Twenty-two homes in Victorville were swept away by flooding of the Mojave River, as were railroad lines, roads, and bridges.	Kern, Los Angeles, Mono, San Bernardino
January 1943	Victorville, Mojave River Basin	Alluvial Fan, Flash, Debris Flow, Stormwater	Approximately 36,000 acres were inundated, streets and bridges were damaged, and all highways surrounding Victorville were blocked. About 80 percent of the damage occurred in urban areas, with the remainder on agricultural lands.	Inyo, San Bernardino
August 1959	Mojave River	Alluvial Fan, Debris Flow, Flash	Thunderstorms in the area of Essex to Needles washed out bridges, stranded hundreds of travelers, and four cars were carried away by floodwaters. Waves up to 22 feet high washed over U.S. Route 66 at Needles.	San Bernardino
August 1961	Barstow, Victorville, Lucerne Valley, Bell Mountain	Flash, Debris Flow	Runoff from thunderstorms eroded roads at Barstow and closed others, with mud and water flows at Victorville and Lucerne Valley. Homes were smothered in mud at Bell Mountain.	San Bernardino
August 1963	Newberry Springs, Apple Valley, Lenwood, Barstow	Flash, Debris Flow	Ten inches of mud invaded 30 homes in Newberry Springs. Flooding was 3 feet deep in Apple Valley. Flash floods disrupted traffic and endangered lives in Lenwood and Barstow.	San Bernardino
November 1965	Wrightwood, Mojave	Alluvial Fan, Flash	San Bernardino County was declared a disaster area by Governor Reagan. Six people lost their lives and flooding caused an estimated $11 million in damages.	San Bernardino
December 1966-January 1967	Inyo County, Mammoth Lakes, Rock Creek, Aspen Springs	Flash	Flooding during the winter of 1966-1967 took three lives and inundated 142,000 acres of agricultural land. There was much storm damage to roads and to the Los Angeles Aqueduct.	Inyo, Kern
January-February 1969	Regionwide	Alluvial Fan, Flash, Slow Rise	Rainfall intensities, amounts and runoff peaks were greater than the 1938 event, except for the Mojave River and its tributaries.	Kern, Inyo, Mono, San Bernardino
January 1973	Countywide	Flash	Severe flooding estimated $86,207 in damages.	Kern
February-March 1978	Mojave River	Alluvial Fan, Debris Flow, Flash	Infrastructure sustained damage from Elizabeth Lake Canyon and from Little Rock and Big Rock creeks. The Mojave River flows damaged levees from Victorville to Barstow and at isolated locations up- and downstream.	San Bernardino
September 1981	Northern Owens Valley	Flash, Structure Failure	Bishop Creek flows washed out U.S. Highway 396 in Bishop and damaged scores of homes. The creek's flow rate was augmented by failure of North Lake Dam on the North Fork Bishop Creek. High water on Big Pine Creek overtaxed a diversion channel, damaging 85 homes and 5 businesses on the Big Pine Indian Reservation.	Inyo, Mono

Table SL-4. Selected Flood Events, South Lahontan Hydrologic Region

Date	Location	Flood Type	Description	County
September 1982	Inyo County, San Bernardino County	Flash, Stormwater	Flash floods occurred on Bishop Creek. Streets flooded in Victorville. Flooding damages were estimated at $7 million in Inyo County.	Inyo, San Bernardino
August 1983	Owens Valley	Flash, Stormwater	A flash flood inundated 20 vehicles in Barstow, and flash floods occurred in eastern Kern County. Flooding closed State Highway 247.	San Bernardino, Kern
August 1989	Communities of Benton, Hammil, Chalfant Valley, Olancha, Southern Inyo County	Flash	Storms inundated and damaged service roads, damaged retaining walls and protective dikes, and buckled several concrete panels of the Los Angeles Aqueduct near Olancha. Losses totaled more than $200,000.	Inyo
January 1997	Walker River Basin	Flash	Floods damaged roads and private property. Damages were estimated at $78 million.	Mono
February 1998	Countywide	Flash	Flooding during this significant El Niño season resulted in a FEMA Federal Disaster Declaration. Damage was sustained by various flood control and transportation facilities in the county. Several road closures ensued as a result of the storm. Rains continued into May.	Kern, San Bernardino
December 2004-January 2005	Rosamond, Mojave River; Hesperia, Oro Grande	Alluvial Fan, Flash	Heavy rains that began in late December 2004 caused widespread flooding. Impacts sustained to the desert community of Rosamond resulted in a FEMA Federal Disaster Declaration for Individual Assistance. The Mojave River flooded three homes and caused severe damages in the Hesperia and Oro Grande areas.	Kern, San Bernardino
June–August 2008	Garlock, Neuralia, Rand, Mt Whitney Fish Hatchery	Debris Flow, Flash	A strong thunderstorm over the eastern slopes of the Sierra Nevada resulted in debris flows that damaged public and private property near Independence. Damage was inflicted on several structures at the Mt. Whitney Fish Hatchery, several homes below the hatchery, a campground, Highway 395, and property on a tribal reservation.	Inyo, Kern, San Bernardino

3.9.3 History of Flood Response

In the South Lahontan Hydrologic Region, the major types of flooding include slow rise, flash, and alluvial fan flooding. As a result of the regionally specific flood risks, a number of traditional flood management projects have been developed to mitigate those risks. These include construction of a reservoir and improvements to levees and channels.

Flood Management Infrastructure

The South Lahontan Hydrologic Region has two constructed flood management facilities—the multipurpose Mojave Forks Reservoir on the Mojave River and a channel improvement on Oro Grande Wash. Flood management agencies are responsible for operating and maintaining 244 miles of levees, 46 dams, 270 debris basins, and other facilities within the South Lahontan Hydrologic Region; however, not all of these are dedicated for flood management or have flood storage. For a comprehensive list of major infrastructure, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*. Also, flood infrastructure maps for each county are provided in *Attachment D: Summary of Exposure and Infrastructure by County (Mapbook)*.

Flood Management Governance

Although primary responsibility for flood management might be assigned to a specific local entity in the South Lahontan Hydrologic Region, aggregate responsibilities are spread among more than 29 agencies with many different governance structures. Some of the larger agencies in the South Lahontan region include the following:

- Inyo County Public Works
- City of Bakersfield
- City of Kern
- Kern County Water Agency
- Kern Delta Water Agency
- North Kern Water Storage District
- Semitropic Water Storage District
- Eastern Kern County Resource Conservation District
- Mono County
- City of Lancaster
- City of Palmdale
- Los Angeles County Department of Public Works
- San Bernardino County Department of Public Works

A comprehensive list of agencies can be found in *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

Flood-Related Regulations

Several agencies within the region have implemented regulations that directly impact flooding and flood management and land use within floodplains. For example, Los Angeles County has streams in the Antelope Basin that have been designated as floodways. This limits what can be constructed within the floodway from specific design storm events (e.g., 100-year event). San Bernardino has designated the Mojave River and streams near and entering Lake Arrowhead as floodways. City-designated floodways include Bishop Creek at Bishop, Anaverde and Little Rock Creeks at Palmdale, local streams in the vicinity of Ridgecrest, and Oro Grande Wash at Victorville.

San Bernardino County adopted an ordinance in 1996 to regulate development in and around Swarthout Creek, Mojave River and Forks Reservoir, Silverwood, and Green Valley. Kern County has had general floodplain zoning ordinances since 1974, along with a review system for building permits. Inyo County identifies flood hazard areas near Ridgecrest. Bishop, Palmdale, Ridgecrest, and Victorville also have ordinances for identifying flood hazard areas. Los Angeles County applies building and subdivision codes to identify flood hazard areas in Antelope Valley. Following severe flooding in Antelope Valley in 1980, 1983, and 1987, the Los Angeles Department of Public Works (LADPW) prepared a comprehensive plan of flood control for the valley. The plan proposed floodplain management in hillside areas, structural improvements in urbanizing areas, including open channel conveyances and storm drains through communities, and detention and retention basins at the mouths of the large canyons, as well as nonstructural management approaches in the rural areas. However, the county has limited revenue to fund the construction. Both the City of Palmdale and the

City of Lancaster have incorporated major elements of the plan developed by LADPW into their own planning. Local land use jurisdictions have adopted floodplain management ordinances, identifying 100-year floodplains and floodways to qualify for participation in FEMA's NFIP.

Flood Emergency Planning Efforts

Emergency management is important because these programs can be used to inform the public, policymakers, and local agencies how to respond to a flood event, which can help save lives when a flood event occurs. In the South Lahontan region, local agencies have developed MHMPs and participate in NFIP.

Multi-Hazard Mitigation Plans. FEMA-approved MHMPs were identified or collected for Kern, Los Angeles, Mono, and San Bernardino counties. For a list of entities in the South Lahontan region that have adopted MHMPs with the corresponding dates of FEMA approval of these plans, refer to Appendix D. Other risk assessment studies were prepared by various entities, including USACE, FEMA, and the State Reclamation Board of California. For a comprehensive list of risk assessment studies, refer to *Attachment G: Risk Information Inventory*.

Flood Insurance. FEMA has provided FIRMs for most areas within the region. Maps in three of the region's five counties were prepared after 2008. Los Angeles County participates in the CRS program.

3.9.4 Current Flood Management

In the South Lahontan Hydrologic Region, 33 local and USACE flood management projects or planned improvements were identified. Twenty-nine of these projects have estimated costs totaling approximately $170 million. Twenty-one local planned projects use an IWM approach to flood management, with estimated costs of approximately $130 million. An example of a project with an IWM approach that combines a flood management component and ecosystem restoration is the West Walker River Restoration Plan. The goal of this project is to develop a restoration plan via the completion of an assessment of the riverine and riparian conditions associated with approximately 3 miles of the West Walker River, located within the area of Antelope Valley that is designated as an economically disadvantaged community.

In addition, DWR administers the IRWM Grant Program. This program has supported the development of three IRWM plans in the region, one of which discusses flood management issues. The Antelope Valley IRWM Plan (2010) recommends the implementation of a number of flood management-related projects, including the development of a Flood Management Plan for the entire Antelope Valley, construction of additional detention basins and associated control structures in the Palmdale area, and construction of a storm drain in Quartz Hill (Antelope Valley RWMG, 2010).

3.10 Tulare Lake Hydrologic Region

3.10.1 Regional Setting

The Tulare Lake Hydrologic Region includes the southern portion of the San Joaquin Valley, extending from the crest of the Coast Ranges on the west to the crest of the Sierra Nevada on the east, and north to south from the Kings River watershed to the Transverse Ranges. The dominant topographic features are four large but shallow sinks, of which Tulare Lake is the lowest and the largest, and broad alluvial fans emanating from the Sierra Nevada at the principal streams—the Kings, Kaweah, Tule, and Kern rivers. All streams except the Kings River nominally flow solely into the sinks of the region; the Kings River natural flow is into Tulare Lake for low to moderate flows and into both the lake and the San Joaquin River during high runoff. However, nearly all runoff of all streams is diverted for irrigation or other purposes.

Lake Success

Significant geographic features include the southern half of the San Joaquin Valley where Tulare Lake is located. Other major features include the Temblor Range to the west, the Tehachapi Mountains to the south, and the southern Sierra Nevada to the east all surrounding the valley, allowing no outlet to the sea. For this reason the area naturally drains to the Tulare, Buena Vista, and Kern lakebeds (natural drainage sinks converted to agricultural areas). Major lakes and reservoirs include Pine Flat Lake, Lake Kaweah, Lake Success, and Lake Isabella. Major streams and rivers include Kings, Kaweah, Tule, and Kern rivers. Major cities include Bakersfield, Visalia, Fresno, Clovis, Tulare, and Delano.

In the Tulare Lake Hydrologic Region, nearly 500,000 people and $32 billion in assets are exposed to the 500-year flood event. The region has the highest crop value (more than $2.3 billion) that is exposed to a 500-year flood in California. One hundred ninety-seven plant and animal species that are State- or Federally listed as threatened, endangered, or rare are exposed to flood hazards in the region. Table TL-1 provides a snapshot of people, structures, crops, infrastructure, and sensitive species exposed to flooding in the region.

The Tulare Lake Hydrologic Region is divided into several main hydrologic subareas—the alluvial fans for the Sierra foothills and basin subarea, bed of

Tulare Lake, and the southwestern uplands. The dominant hydrologic features in the alluvial fan/basin subareas are Tulare Lake and the Kings, Kaweah, Tule, and Kern rivers and their major distributaries. All of the streams in Tulare Lake Hydrologic Region are diverted for irrigation or other purposes. The valley floor is flat, and the entire volume of most of the larger streams flows into multiple channels and irrigation canals, reaching Tulare Lake only in years of extremely high runoff. Figure TL-1 illustrates the location of major features in the region, including streams and rivers.

The San Joaquin Valley's long growing season (April through October), warm/hot summers, and a fall harvest period usually sparse in rain provide a near-ideal environment for production of many crops. Winters are moist and often blanketed with tule fog. Nearly all of the year's precipitation falls in the 6 months from November to April. The valley floor is surrounded on three sides by mountain ranges, virtually isolating the valley from marine effects.

Table TL-1. Tulare Lake Hydrologic Region Exposures within the 100-Year and 500-Year Floodplains

Segment Exposed	100-year (1%) Floodplain	500-year (0.2%) Floodplain
Population (% total exposed)	134,100 (7%)	498,200 (27%)
Total Depreciated Replacement Value of Exposed Structures and Contents	$8.3 billion	$32.0 billion
Exposed Crop Value	$1.8 billion	$2.3 billion
Exposed Crops (acres)	802,200	990,800
Tribal Lands (acres)	109	109
Essential Facilities (count)	71	254
High Potential-Loss Facilities (count)	50	71
Lifeline Utilities (count)	11	25
Transportation Facilities (count)	538	808
Department of Defense Facilities (count)	7	7
Plant species State- or Federally listed as Threatened, Endangered, or Rare a	94	94
Animal species State- or Federally listed as Threatened, Endangered, or Rare[a]	101	103

Note:

[a]Many Sensitive Species have multiple occurrences throughout the state, and some have very large geographic footprints that may overlap more than one analysis region. As a result, a single Sensitive Species could be counted in more than one analysis region. Because of this, the reported statewide totals will be less than the sum of the individual regions.

Stream Descriptions

Table TL-2 includes a detailed description of each watercourse mentioned in connection with the Tulare Lake Hydrologic Region. All streams end in inland sinks. Avenal Creek and Cottonwood Creek end at the northernmost sink, Sunflower Valley. All main streams except the Kern River nominally end in Tulare Lake; the Kern River ends in Buena Vista Lake, which may overflow to Tulare Lake. The descriptions in the table begin with Sunflower Valley, proceed clockwise around Tulare Lake, beginning with the Kings River, and then cover Buena Vista Lake. Descriptions proceed upstream, listing tributaries and distributaries, with secondary tributaries listed following each primary tributary. Distributaries are listed at the point of diversion and not listed where they enter another listed stream. Indentations, sub-letters, and numbers indicate tributary status.

Tulare Lake Rivers

Figure TL-1 Rivers and Streams of the Tulare Lake Hydrologic Region

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

Table TL-2. Stream Descriptions, Tulare Lake Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
STREAMS TRIBUTARY TO SUNFLOWER VALLEY					
1	Avenal Creek	Chalk Buttes SW of Avenal	SE, S		Sunflower Valley
2	Cottonwood Creek[i]	Bluestone Ridge W of Devils Den	NE		Sunflower Valley
STREAM SYSTEMS TRIBUTARY TO TULARE LAKE					
3	Kings River[a]	Sierra Nevada crest in Kings Canyon National Park	SW	Pine Flat Lake	South of Stratford
3A	Los Gatos Creek (Arroyo Pasajero)	Coast Range crest N of Coalinga	SE, NE		W of Lemoore
3A1	Zapato Chino Creek	Mustang Peak W of Avenal	NE		W of Huron
3A2	Warthan Creek	Juniper Ridge W of Coalinga	SE, NE		E of Coalinga
3B	Crescent Bypass	SW of Riverdale	S		NW of Lemoore
3B1	North Fork Kings River[j]	N of Lemoore	W		NW of Lemoore
3B1a	Fresno Slough	NW of Lemoore	NW		San Joaquin River at Mendota Pool
3B1a1	Cantua Creek	Crest of the Coast Ranges at Santa Rita Peak	NW		Helm
3B1a2	Fish Slough	SW of Helm	NW		James Bypass N of Helm
3B1a2i	James Bypass	N of Helm	NW		Fresno Slough N of Tranquility
3C	South Fork Kings River	W of Hardwick	SW		Kings River N of Lemoore
3C1	Clarks Fork Kings River	NW of Halls Corner	SW		N Fork Kings River N of Lemoore
3D	Cole Slough	S of Kingsburg	SW		Kings River E of Laton
3D1	Dutch John Cut	E of Laton	SW		Kings River SE of Laton
3E	Fresno Canal	N of Minkler	W		Mill Ditch NW of Sanger
3E1	Fancher Creek	S of Humphreys Station	SW	Fancher Creek Reservoir, Fancher Creek Detention Basin	N of Sanger
3E1a	Hog Creek	Stony Point	SW		W of Clovis
3E2	Mill Ditch	NW of Sanger	W		Dry Creek Canal in Central Fresno

Table TL-2. Stream Descriptions, Tulare Lake Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
3E2a	Redbank Slough (Redbank Creek)	SE of Academy	SW	Redbank Creek Reservoir, Redbank Creek Detention Basin	E of Fresno
3E2a1	Dog Creek	N slope of Wildcat Mountain	SW		E of Fresno
3E2b	Dry Creek (Dry Creek Canal)[11]	N of Tollhouse	SW	Big Dry Creek Reservoir, Big Dry Creek Detention Basin	SW of Fresno
3E2b1	Pup Creek	NE of Clovis	SW	Pup Creek Detention Basin	Clovis
STREAM SYSTEMS TRIBUTARY TO TULARE LAKE					
3E2b2	Alluvial Drain	NE of Clovis	SW	Alluvial Drain Detention Basin	N of Clovis
3F	Enterprise Canal	NE of Minkler	NW, SW		Herndon Canal in W Fresno
3F1	Gould Canal	NW of Minkler	W		Herndon Canal in central Fresno
3F1a	Mud Creek	Coyote Ridge NW of Sanger	SW		N of Sanger
3F2	Holland Creek	SW slope of Red Mountain	S		NE of Minkler
3G	Mill Creek	Kings Canyon National Park at Big Stump	W, NW		Below Pine Flat Lake
3H	North Fork Kings River[k]	Sierra Nevada Crest along LeConte Divide	W, S, W		In Pine Flat Lake
3I	Tenmile Creek	Kings Canyon National Park N of Buena Vista Peak	N		W of Horseshoe Bend
4	Cross Creek	N of Goshen	S		S of Corcoran
4A	Cottonwood Creek[l]	N of Auckland	S, NW, SW		N of Goshen
5	Kaweah River	Sequoia National Park along and W of the Great Western Divide	W to S, SW	Lake Kaweah	Many distributaries W of Lake Kaweah tending toward Tulare Lake
5A	Deep Creek	N of Exeter	SW		SE of Corcoran
5A1	Cameron Creek	N of Exeter	SW		NE of Corcoran
5B	Consolidated Peoples Ditch	S of Woodlake	SW		Distributaries NE of Farmersville
5B1	Yokohl Creek	Blue Ridge E of Lindsay	NW		N of Exeter

Table TL-2. Stream Descriptions, Tulare Lake Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
5B2	Locust Ditch	NW of Exeter	S		Farms SW of Lindsay
5B2a	Lewis Creek	Blue Ridge E of Lindsay	W		W of Lindsay
5C	St. Johns River	McKays Point	W		Cross Creek N of Goshen
5C1	Mill Creek	S of Ivanhoe	SW		SE of Hanford
5C1a	Packwood Creek	N of Farmersville	SW		W of Tulare
5D	Wutchumna Ditch	N of Lemon Cove	W		St. Johns River NE of Visalia
5D1	Antelope Creek	Long Mountain N of Woodlake	S		S of Woodlake
5E	Dry Creek (Limekiln Creek) (Tulare County)	Kings Canyon National Park E of Big Stump	S		Below Lake Kaweah
STREAM SYSTEMS TRIBUTARY TO TULARE LAKE					
5F	South Fork Kaweah River	Quinn Peak	W, NW		S of Three Rivers
5G	Middle Fork Kaweah River	Kings-Kaweah Divide	SW, S		N of Three Rivers
6	Tule River	S central Sierra Nevada E of Springville	W	Lake Success	SW of Corcoran
6A	Lewis Creek	Blue Ridge E of Lindsay	W, NW, SW		NW of Woodville
6B	Frazier Creek	Sierra Nevada foothills E of Strathmore	W, SW		W of Porterville
6A	South Fork Tule River	Slate Mountain E of Porterville	W		In Lake Success
6B	North Fork Tule River	Moses Mountain	W, SW, S		NE of Springville
7	Deer Creek	N Greenhorn Mountains	W		N of Alpaugh
7A	Fountain Springs Gulch	Galley Mountain W of Fountain Springs	W, NW		N of Terra Bella
8	White River	Central Greenhorn Mountains	W		Near Allensworth
9	Poso Creek	S Greenhorn Mountains	W		W of Delano
STREAM SYSTEMS TRIBUTARY TO BUENA VISTA LAKE[b]					
10	Kern River	Sierra Nevada crest along Kings-Kern Divide	S, SW	Lake Isabella	Buena Vista Lake[d]
10A	Jerry Slough[f]	San Joaquin Valley floor E of Buttonwillow[e]			Goose Lake
10B	California Aqueduct[c,g]	Sacramento-San Joaquin Delta NW of Tracy	SE		Lake Silverwood and Lake Perris
10C	Friant-Kern Canal[h]	Friant Dam NE of Fresno	SE		Kern River W of Bakersfield
10D	Caliente Creek	S Piute Mountains NE of Tehachapi	W		Valley floor N of Arvin

Table TL-2. Stream Descriptions, Tulare Lake Hydrologic Region

Stream ID	Stream	Origin	Flow Direction	Flood Control Reservoirs	Mouth Location
10D1	Walker Basin Creek	Central Piute Mountains and Walker Basin	SW		NE of Lamont
10D2	Tehachapi Creek	Tehachapi Mountains S of Tehachapi	N, NW	Antelope Stormwater Collection Facility	Caliente
10D2a	Blackburn Creek	Tehachapi Mountains S of Tehachapi	N	Blackburn Stormwater Collection Facility	W of Tehachapi
STREAM SYSTEMS TRIBUTARY TO BUENA VISTA LAKE[b]					
10E	Clear Creek[m]	N Piute Mountains	NW, N		Miracle Hot Springs
10E1	Havilah Creek	Red Mountain	N		N of Havilah
10F	Erskine Creek	N Piute Mountains SE of Kernvale	NW		S of Kernvale
10G	South Fork Kern River	Sierra Nevada crest S of Army Pass	S, W		In Lake Isabella
10G1	Kelso Creek	E Slope of Piute Mountains	E, N		Near Weldon

Key:

E East, easterly, eastern

N North, northerly, northern

S South, southerly, southern

W West, westerly, western

Notes:

[a]The Kings River nominally flows to Tulare Lake, but in times of high runoff it may be diverted or partially diverted to the San Joaquin River through Fresno Slough.

[b]In years of extremely high runoff, Buena Vista Lake can overflow into Tulare Lake.

[c]A limited amount of water may be diverted for flood management by agreement with DWR through the Kern River Intertie SW of Bakersfield.

[d]The Kern River may be diverted northwestward to Tulare Lake through the Kern River Flood Canal.

[e]May be supplied in high water periods at this location by Goose Lake Slough, which originates at the Kern River W of Kern City.

[f]Tributary to the Kern River Flood Canal.

[g]Distributary from the Kern River Flood Canal.

[h]A limited amount of water may be diverted for flood control by agreement with Reclamation by pumping into the canal.

[i]Kings and Kern Counties

[j]Kings County

[k]Fresno County

[l]Tulare County

[m]Kern County

Peak Flows

Table TL-3 provides peak flow information in the Tulare Lake Hydrologic Region and shows a correlation between significant flood events and peak flows.

- The most recent peak discharge was observed in 2002 on South Fork Tule River.
- The highest peak discharge recorded on two streams was more than 40,000 cfs.

Table TL-3. Record Flows, Tulare Lake Hydrologic Region

Stream	Location	Mean Annual Runoff (taf)	Peak Stage of Record (feet)	Peak Discharge of Record (cfs)	Date of Peak Discharge
Middle Fork Kaweah River	Near Potwisha Camp[c]	105[b]	29.0	46,800	12/23/1955
North Fork Kings River	Below Dinkey Creek, near Balch Camp	248	19.2	27,400	2/1/1963
Kern River	Near Democrat Springs	480[b]	18.6	10,100	12/6/1966
Kern River	Near Kernville	344[b]	24.4[a]	60,000	12/6/1966
South Fork Kern River	Near Onyx	90	18.9	28,700	12/6/1966
North Fork Kings River	Near Cliff Camp	33[b]	12.0	5,110	12/5/1978
Los Gatos Creek	Above Nuñez Canyon, near Coalinga	4	14.0[a]	5,700	3/10/1995
South Fork Tule River	Near Reservation Boundary	23	13.0	5,060	11/8/2002

Key:

cfs = cubic feet per second   taf = thousand acre-feet

Notes:

[a]Different date than peak discharge.

[b]Most recent but less than period of record.

[c]Low-flow gauge only, beginning 2004.

The stations included in this table were selected from all USGS gauging stations in the hydrologic region, according to the following criteria:

- The watercourse must be a natural stream with a watershed of at least 100 square miles.
- The station must have a reasonably continuous record of discharge from 1996 to the present.
- The station must be far enough from other stations on the same river to reasonably represent a separate condition.
- Stations in well defined watercourse locations such as deep canyons are omitted, unless particularly important to the overall flood situation.

3.10.2 Historic Floods

Flood damage has been observed in the Tulare Lake Hydrologic Region since at least 1805. Most floods of the Tulare Lake Hydrologic Region are the slow rise type. Structural failures of flood protection works occur occasionally. Additionally alluvial fan, debris flow, flash and stormwater flooding occur in the region. Table TL-4 presents an abridged synopsis of flood events in the region. For a more comprehensive list of flood events in the region, see Appendix B. Selected significant floods are briefly discussed below.

Southern Pacific Locomotive in Visalia, CA, 1906

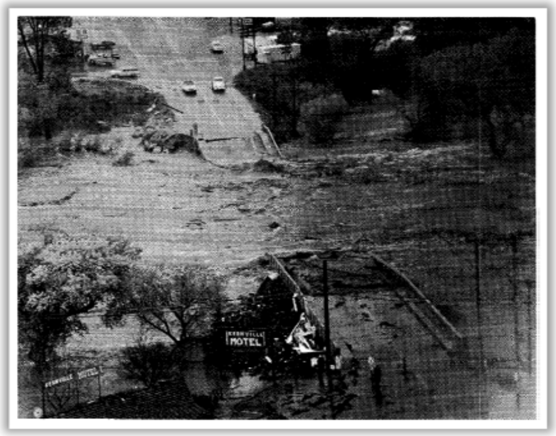
1861-62: The "Great Flood." The 1861-62 flood caused channel changes in all four principal rivers. Cole Slough began to form, becoming a principal northward distributary of the Kings River. A new distributary, the St. John's River, was created for the Kaweah River. The Tule River eroded a new main channel, now called Porter Slough. The Kern River eroded a new channel to the northwest, bypassing Kern Lake and perhaps Buena Vista Lake. The Kings River washed away the entire town of Scottsburg, which was reestablished on higher ground. A 30-foot wave on Mill Flat Creek was created by washout of a debris plug destroyed two sawmills. Mill Creek produced shallow flooding in downtown Visalia three times, contaminating wells, destroying four bridges, and destroying 46 houses and a majority of business buildings. The Kings, Kaweah, and Tule rivers brought down tremendous quantities of timber from the Sierra and deposited them on the plains. The Kern River flows caused major damage in the mining district, destroying nearly all bridges, dams, and mills. There was a major debris slide on the South Fork Kern River.

Tulare County Flood, 1906

1906. All streams and rivers in the Kaweah and Tule River Basins were flooded. Hundreds of acres were inundated. The St. John's River levee broke, and water poured into Visalia from the north.

November-December 1950. Floods damaged Centerville, Visalia, Porterville, Oildale, Isabella and Kernville. The Kings River washed out the weir, cofferdam, and foundation work of Pine Flat Dam and flooded nearly 70,000 acres from Piedra to Tulare Lake and the San Joaquin River, encroaching on Laton, Riverdale, and Hardwick. The Kern River in the canyon area flooded three power plants, destroyed the State fish hatchery, inundated summer homes, and damaged highways along with commercial and recreational facilities.

December 1955-January 1956. A storm caused by a group of cyclones from the mid-Pacific Ocean poured rain and induced snowmelt on low elevations of the Tulare Lake Hydrologic Region. Roads and bridges were damaged in the Kings River Canyon and along the Kaweah River and tributaries near Ash Mountain. Thousands of acres were flooded west of Porterville. More than 15 inches of rain fell in 2 days and caused flooding along the Kern River. The state fish hatchery was washed away. Flooding was significant in Visalia.



Bridge over Kern River at Kernville, 1966

December 1966. Significant flooding occurred along Los Gatos, Warthan, and Avenal creeks, damaging roads, sewage treatment facilities, levees, utilities, and farmland. At Three Rivers, roads, bridges, and transmission/ distribution lines were damaged or destroyed; homes, businesses, and a county park were washed out; the Kaweah River cut a new channel across the Three Rivers Golf Course. Uncontrolled spill from Lake Success contributed to the agricultural flooding. The Tule River breached levees near Porterville and flooded the Pixley National Wildlife Refuge.

Flood- Bank Protection taken by local interests using car bodies, 1969

January-June 1969. Heavy precipitation plus a prodigious snowpack melt caused flooding in the region. Parts of Dinuba, Orosi, East Orosi, Cutler, and Yettem were flooded by overflowing irrigation canals. Kaweah River washed away the public beach south of Three Rivers. White River levee breached, closing U.S. Highway 99. All measures available were taken to reduce inundation of the rich farmlands of the Tulare Lake bottom. Water was routed from the Kings River through Fresno Slough to the San Joaquin River, until it was limited by high water on that river. Water was diverted away from Tulare Lake through interagency cooperation into the Friant-Kern Canal and the California Aqueduct. Interior leveed cells of the lake were filled to capacity by pumping before additional cells were allowed to be filled, and the USACE constructed levees and improved channels. Nevertheless, the inundated acreage steadily increased from January to June, until nearly 89,000 acres were covered. The lake persisted until about 1972.

February-May 1998. La Niña conditions produced flooding throughout the spring. Coast Range runoff inundated farmland around Mendota and Cantua Creek. The White River inundated the city of Earlimart and closed U.S. Highway 99 for a week. Accumulated stormwater created ponds on many roads in Bakersfield. Tulare Lake continued to receive runoff, and great quantities of water were exported to Southern California and the San Joaquin River.

Table TL-4. Selected Flood Events, Tulare Lake Hydrologic Region

Date	Location	Flood Type	Description	County
1805	Regionwide	Slow Rise	The flood of 1805 inundated the entire valley floor.	Fresno, Kern, Kings, San Benito, Tulare
December 1861-March 1862	Kern, Kaweah, Kings, Tule, Mill Creek and White River	Slow Rise, Debris Flow	The 1861–62 flood period was remarkable for the exceptionally high stages reached on nearly every stream, for repeated large floods, and for the prolonged and widespread regional inundation.	Fresno, Kern, Kings, Tulare
December 1867-January 1868 "Great Kern River Flood"	Kern River, Three Rivers, Kaweah River, Mill Creek, Tule River	Slow Rise, Debris Flow, Structure Failure	The December 1867-January 1868 Tulare Lake Basin flood is considered the greatest in the region since European settlement began. Total basin runoff is estimated by Reclamation to have exceeded the measured 1983 record.	Fresno, Kern, Kings, Tulare
1906	St. John's River, Kaweah River, Tule River	Structure Failure	All streams and rivers in the Kaweah and Tule River Basins were flooded. Hundreds of acres were inundated. The St. John's River levee broke, and water poured into Visalia from the north.	Fresno, Kings, Kern Tulare
July 1907	Buena Vista, Lake Levee, Kings, Kern, Kaweah	Slow Rise, Structure Failure	On July 3, the levee that constrained Buena Vista Lake failed. The resulting flood inundated 25,000 to 30,000 acres south and west of Bakersfield, including the old bed of Kern Lake. It damaged 12 miles of the Sunset Railroad. Total inflow to the lake in water year 1907 was 977,000 acre-feet, raising the elevation by 6.7 feet.	Fresno, Kern, Kings, Tulare
1909	Kern River, Tule River, Tulare Lake, Kaweah	Slow Rise, Structure Failure	A major flood occurred along the Kaweah, Tule, Kings and Kern rivers. Levees failed at both Visalia and Porterville. Twenty-five families living in the lower part of Porterville were rescued by other town citizens.	Fresno, Kern, Kings, Tulare
February 1937	Kern River near Fruitvale, Fairhaven, Kings River	Alluvial Fan	Damage occurred along the Kings and Kaweah rivers. There was considerable damage to Generals Highway and to Colony Mill Road. The Fruitvale and Fairhaven areas near Meadows Field were flooded, and 16 people had to be rescued by boat in those areas. Over 50 people were evacuated, and all of their homes were destroyed or badly damaged.	Fresno, Kern
November-December 1950	Regionwide, Kern River, Bakersfield	Slow Rise, Stormwater, Structure Failure	Floods damaged Centerville, Visalia, Porterville, Oildale, Isabella, and Kernville. The Kings River washed out the weir, cofferdam, and foundation work of Pine Flat Dam and flooded nearly 70,000 acres from Piedra to Tulare Lake and the San Joaquin River, encroaching on Laton, Riverdale, and Hardwick.	Fresno, Kern, Kings, San Benito, Tulare
December 1955-January 1956 "Christmas Day Flood"	Eastern Fresno County and Valley Region, Kern River, Tulare Lake, Kaweah River system; Visalia, Three Rivers, and Exeter	Slow Rise, Debris Flow, Alluvial Fan, Structure Failure	A storm caused by a group of cyclones from the mid-Pacific Ocean poured rain and induced snowmelt on low elevations of the Tulare Lake Hydrologic Region.	Fresno, Kern, Kings, San Benito, Tulare

Table TL-4. Selected Flood Events, Tulare Lake Hydrologic Region

Date	Location	Flood Type	Description	County
March 1958	West of Mendota,	Slow Rise, Debris Flow	There were 22 days of storms during March. The biggest storm occurred March 11 through 17, dropping 38 inches on Giant Forest and 52 inches on Grant Grove. On March 16, heavy rain triggered debris flows that caused a bridge to wash out 21 miles west of Mendota. A car drove into the raging water, resulting in one boy being killed.	Fresno, Kings, San Benito
1962- 1963	Kernville, Lake of the Woods	Slow Rise, Alluvial Fan	Flood damage to agricultural and public facilities during the 1962-63 flood was particularly serious along the streams flowing from west-side tributaries.	Fresno, Kern, Kings, Tulare
September 1963	Highway 178 and El Paso Wash	Flash	A high-intensity rain in the El Paso Mountain area overwhelmed the storm culverts at Highway 178 and El Paso Wash, which overflowed both sides of the highway into the U.S. Naval Weapons Center, which sustained damages totaling $278,000.	Kern
December –January 1964-1965	Kings River	Slow Rise, Debris Flow	Warm, moist air collided with the arctic air and resulted in turbulent storms that produced unprecedented rainfall on Northern California and melted much of the snow from previous storms. The heavy rains caused some damage to Generals Highway.	Fresno, Kings
December 1966-January 1967	Kings River, Kern River, Tulare Lake Basin, Caliente Creek	Slow Rise, Alluvial Fan, Debris Flow, Structure Failure	Flooding during the winter of 1966-67 took three lives and inundated 142,000 acres of agricultural land. Significant flooding occurred along Los Gatos, Warthan, and Avenal Creeks, damaging roads, sewage treatment facilities, levees, utilities, and farmland.	Fresno, Kern, Kings, Tulare
January 1969- February 1969 "Winter '69 Storms"	Ridgecrest - Jacks Ranch Road; Tulare lake Bed	Slow Rise	Heavy precipitation plus a prodigious snowpack melt in January and February 1969 caused flooding throughout the region and re-inundated 89,000 acres of the Tulare Lakebed.	Kern
January 1969- February 1970	Tulare Lakebed	Slow Rise	Heavy precipitation plus an extraordinary snowpack melt caused flooding in the region. Even normally dry Deer Creek was flowing into the Tulare Lakebed in the spring.	Kern, Kings, San Benito, Tulare
March-April 1974	Poso Creek	Slow Rise	Poso Creek overflowed, damaging agricultural lands.	Kern
January-March 1978	Kern River - Bakersfield, Poso Creek - MacFarland, Kelso Creek, Caliente Creek - Lamont, Caliente Creek and other streams	Alluvial Fan	Severe flooding occurred in Kern County, covering more than 6,000 acres. Caliente Creek flooded the Lamont/Arvin area. Debris flows were numerous. Floods damaged infrastructure, including the California Aqueduct. Oilfield facilities were also damaged. Los Gatos Creek flooded about 4,500 acres near Coalinga. Flooding occurred in the Tulare Lakebed.	Kern, Kings, San Benito

Table TL-4. Selected Flood Events, Tulare Lake Hydrologic Region

Date	Location	Flood Type	Description	County
December 1982-March 1983	Regionwide	Alluvial Fan	Cottonwood and Cross creeks overflowed and damaged farmland. Caliente Creek destroyed 15 homes, damaged 50 more, and obliterated 12 miles of local roads near Caliente, then inundated Lamont and deposited silt throughout the area. Floods closed northbound U.S. Highway 99 in February. Many roads were closed, and many bridges and culverts were clogged with silt. Generally wet conditions damaged crops and cut dairy production. Stormwaters flooded streets in Visalia and Lindsay. Tulare Lake received inflow, flooding 82,000 acres of farmland.	Fresno, Kern, Kings, San Benito, Tulare
January-March 1995	Western Fresno County, Caliente Creek - Lamont, Kelso Creek - Weldon, Mendota, Huron, Lamont, Arvin, Loraine, Maricopa, Fraizer Park	Flash, Stormwater, Slow Rise	An El Niño year contributed a string of subtropical storms that struck the region. Mendota experienced flooding and road damage. Severe flooding in Los Gatos Creek (Arroyo Pasajero) destroyed two bridges on Interstate 5 near Coalinga, and seven people were killed. Los Gatos Creek ruptured an 18-inch oil line, and Zapato Chino Creek washed out a 66-inch irrigation line. State Highway 269 was closed for 72 days near Huron. Caliente Creek flooded Lamont, and crops were damaged at Arvin.	Fresno, Kern, Kings, San Benito, Tulare
January 1997	Regionwide	Slow Rise, Structure Failure, Debris Flow, Flash	This event has been called the largest flood disaster in California history, but effects were moderate in this region. Flooding along the Kings River and tributaries caused damage to bridges, roads, and other property in the Sequoia and Kings Canyon National Parks. A bridge on Interstate 5 over the Kings River was washed out. Overflows from Ten Mile Creek damaged a summer camp. Levees breached on the Tule River and Poso Creek. A bridge in Porterville was damaged. White River flooded Earlimart, closing U.S. Highway 99 for more than a week and submerging 48,000 acres of agricultural lands in the Tulare Lakebed.	Fresno, Kern, Kings, San Benito, Tulare
January- June 1998	Regionwide	Slow Rise, Flash	Coast Range runoff inundated farmland around Mendota and Cantua Creek. Approximately 9,300 acres of farmland were flooded. The White River inundated the City of Earlimart and closed U.S. Highway 99 for a week. Accumulated stormwater ponded on many roads in Bakersfield.	Fresno, Kern, Kings, San Benito, Tulare
December 2005-January 2006	Cities of Fresno and Clovis	Flash, Debris Flow	Severe storms induced flooding, mudslides, and landslides.	Fresno

3.10.3 History of Flood Response

In the Tulare Lake Hydrologic Region, the major types of flooding include slow rise, flash, and stormwater flooding. As a result of and in response to the regionally specific flood risks, a number of traditional flood management projects have been developed. These include construction of an extensive system of lakes and reservoirs, levees, sediment basins, and channels.

Flood Management Infrastructure

The Tulare Lake Hydrologic Region has flood management facilities for the protection of cities and agricultural areas, particularly for the valuable lakebed farmlands. Installations include the Kings River Flood Control Project, four multipurpose reservoirs with flood management reservations, four major single-purpose flood management reservoirs, five smaller flood management reservoirs, a sedimentation basin, diversions, weirs, levees, and channel improvements.

The Kings River Flood Control Project uses weirs, levees, and channel improvements to contain the flows of the Kings River, Crescent Bypass, North Fork Kings River, Fresno Slough, South Fork Kings River, Clarks Fork Kings River, Cole Slough, and Dutch John Cut. The flows are then directed toward irrigation facilities, Tulare Lake, or the San Joaquin River as needed.

Caliente Creek Flooding near East Side of Lamont, California, 1983

The Tulare Lake Hydrologic Region is the site of many types of flood management infrastructure, including floodwater storage facilities and channel improvements that were partially funded or co-sponsored by State and Federal agencies. Flood management agencies are responsible for operating and maintaining approximately 4,095 miles of levees, more than 50 dams, and other facilities within the Tulare Lake Hydrologic Region; however, not all of these are dedicated for flood management or have flood storage. For a comprehensive list of major infrastructure, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*. Flood infrastructure maps for each county are provided in *Attachment D: Summary of Exposure and Infrastructure by County (Mapbook)*.

Flood Management Governance

Although primary responsibility for flood management might be assigned to a specific local entity in the Tulare Lake Hydrologic Region, aggregate responsibilities are spread among more than 118 agencies with many different governance structures. Some of the larger agencies in the Tulare Lake Hydrologic Region include the following:

- Fresno County Public Works
- City of Bakersfield

- County of Kern
- Eastern Kern County Resource Conservation District
- Kern County Water Agency
- Kings County, Kings River Conservation District
- Tulare County Flood Control District

For a comprehensive list of the entities that have responsibilities or involvement in flood and water resources management, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

Flood-Related Regulations

Several agencies within the region have implemented regulations that directly impact flooding and flood management. For example, Fresno, Kings, Tulare, and Kern counties regulate floodplain development and restrict floodway encroachment with their zoning ordinances. General plans for the four counties discuss flood hazards and management measures in the context of projected population growth, and the plans provide guidelines for future flood management strategies. Local land use jurisdictions have adopted floodplain management ordinances, identifying 100-year floodplains and floodways to qualify for participation in FEMA's NFIP.

The Kern River Parkway Plan and Channel Maintenance Program, adopted by the City of Bakersfield in 1986, protects existing levees and riverfront riparian areas and provide open space recreation along the river. The Kern River Restoration Project, completed in 1991, enhances the Kern River channel and provides for safe carriage of flood flows through the urbanized Bakersfield area.

Flood Emergency Planning Efforts

Emergency management is a significant concern within the Tulare Lake Hydrologic Region due to the risk of engineered structure failure and slow rise flooding.

Multi-Hazard Mitigation Plans. FEMA-approved MHMPs were identified or collected for Fresno Kings, Kern, and Tulare counties. For a complete list of the entities in the Tulare Lake region that have adopted MHMPs, with the corresponding dates of FEMA approval, refer to Appendix D. Other risk assessment studies were prepared by various entities, including USACE, FEMA, and the State Reclamation Board of California. For a comprehensive list of risk assessment studies, refer to *Attachment G: Risk Information Inventory*.

Flood Insurance. FEMA has provided FIRMs for all areas within the region. Maps in all of the region's six counties have been prepared since 2008. In the Tulare Lake Hydrologic Region, Fresno and Kern counties, as well as the cities of Visalia and Fresno participate in the CRS program.

3.10.4 Current Flood Management

In the Tulare Lake Hydrologic Region, 37 local and USACE flood management projects or planned improvements were identified. Of those 37 projects, 33 projects have costs totaling approximately $770 million. Twenty-two of the projects use an IWM approach, with identified costs of approximately $240 million. Two examples of local IWM project are the River Ranch Valley Oak Habitat Restoration & Groundwater Recharge Project, and the South Fork Kings River Project, which will protect environment and habitat. For a comprehensive list of identified local planned projects, refer to *Attachment E: Existing Conditions of Flood Management in CA (Information Gathering Findings)*.

In addition, DWR administers the IRWM Grant Program. This program has supported development of IRWM plans in the region. Two of the four IRWM plans in this region address flood control.

- *Westside Regional Drainage Plan*, adopted in 2003, proposes constructing a flood detention reservoir on Arroyo Pasajero within retired farm lands (San Joaquin River Exchange Contractors Water Authority et al., 2003).
- Upper Kings Basin Water Forum of 2009 addressed the importance of curtailing flood damages through structural works, floodplain management, and conjunctive uses. It has two projects directed toward enhanced flood management, and a number of conjunctive use projects that have ancillary flood management benefits.

Markleeville Flooding, 1937

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4.0 Findings

4.1 Findings on Flood History

Flood history in California is complex and includes many events that have minimal documentation, especially for events in the more distant past. Due to the varying levels of information available, the detail that can be provided on specific flood events is not always consistent. Currently, no statewide or regionwide repository exists for flood history information that would allow easy sharing of this information.

California faces a challenging future due to existing and increasing flood risk. Approximately 7 million people and $580 billion in assets are exposed to flooding statewide within the 500-year floodplain. Flooding occurs in every part of California in different forms—from tsunamis along the coast to alluvial fan flooding in the deserts, and from deep flooding in the Central Valley to flash flooding in southern California. Flood management is the responsibility of a complex array of more than 1,300 agencies with more than 40 different governance structures. These agencies are responsible for operating and maintaining approximately 20,000 miles of levees, 1,500 dams, and 1,000 debris basins.

Flood management has transformed over time as a result of changes in financing, societal views, and innovations in management approaches. Flood management practices have evolved from structural measures (such as dams, levees, and debris basins) to include nonstructural management actions (such as flood emergency management, public awareness, and system operations). Today flood management is using a multibenefit or integrated approach to address flooding—IWM. IWM is a strategic approach to planning and implementation that combines specific flood management, water supply, and ecosystem actions to deliver multiple benefits.

DWR and USACE support using an IWM approach and have begun to structure flood management programs in this way. Local agencies are also evolving toward using an IWM approach. The Flood Future Report has identified over 300 local and USACE IWM projects with costs of more than $6 billion (almost 20 percent of the identified projects do not have costs). IWM changes the implementation approach based on the understanding that water resources, including flood management, are an integral component for sustainable ecosystems, economic growth, water supply reliability, public safety, and other interrelated elements.

4.2 Suggestions for Updating the Flood History TM

This TM is an initial effort to compile a diverse set of sources and information from various statewide agencies and other resources (e.g., flood experts). Information varies from source to source on specific data regarding flood history, flood infrastructure, and flood emergency management. Based on the findings, the following strategies are the recommended steps forward to build on the flood history information provided in this document:

- Create a statewide repository for flood history information that can serve as a basis for future revisions to this document.
- Develop a database for flood events, including the source and the level of confidence that exists in data.
- Work with local agencies and data repositories to acquire additional information on flood events in California.
- Work with local agencies in acquiring and developing a complete statewide Geographic Information System (GIS) database of infrastructure.
- Continue to improve and refine this document, including annual efforts to document the most recent flood events.
- Compile damage numbers for major flood events and put into a standard base year to compare.
- Develop a standard definition of what constitutes a major flood, refining the definition developed for this document and enabling easier Identification of major flood events.
- Develop a complete list of flood ordinances to help inform how flood management has evolved.
- Develop a database of flood infrastructure statewide.

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DEPARTMENT OF WATER RESOURCES

UNITED STATES ARMY CORPS OF ENGINEERS
FLOOD PLAIN MANAGEMENT SERVICES PROGRAM

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http://www.water.ca.gov/SFMP